western union

Technical Review

VOLUME 21 NO. 1 JANUARY 1967

western union

The purpose of the TECHNICAL REVIEW is to present technological advances and their applications to communications.

committee on technical publication

W. H. Fisher, *Chairman*
J. H. Booth
G. W. Gamble
M. R. Marsh
B. Rider
C. G. Smith
W. H. Watts
R. J. Poulton, *Secretary*

editor

Mary C. Killilea

Address all communications to:
The Editor of *Technical Review*
Western Union
60 Hudson St.
New York, N.Y. 10013

The TECHNICAL REVIEW is published by the Information Systems and Services Department for management, supervisory and technical personnel in Western Union. It is issued quarterly in January, April, July and October.

Subscription Rates:	United States	— $5.00 per year
	Other Countries	— $8.00 per year
Single Copies:	United States	— 50¢ plus handling charge
	Other Countries	— 75¢ plus handling charge
	Handling Charge	— 50¢ per order
Checks:	Make check payable to: Western Union (TECHNICAL REVIEW)	

western union

JANUARY 1967

WESTERN UNION
60 Hudson Street
New York, N.Y. 10013

NEW YORK
NEW YORK

FIRST CLASS MAIL
U. S. POSTAGE
PAID 35 CENTS
PERMIT NO. 697

FIRST CLASS MAIL

James H. Haynes
1809 W. El Caminito
Phoenix, Ariz. 85021

ERRATA in JANUARY 1967 issue

On pg 23 the complete list of operations comprising the J S & S Department relocated in Mahwah, N. J. should have included:

Commercial Projects Operation.

Technical Review

western union

volume 21 number 1 january 1967

contents

Cover: Message Switching Systems

Printed in U.S.A.

message switching in the ARS

Robert H. Leonard

The Advanced Record System placed into service for the General Services Administration in February 1966, is a Telex type Circuit Switch Network augmented with computer based store-and-forward message switching functions. In addition to providing the Circuit Switch Network (CSN) subscribers with store-and-forward Message Switching Center services related to the CSN, the computer configuration will permit two-way communication with AUTODIN and presently delivers CSN originated traffic to TELEX. It will deliver CSN originated traffic to TWX sometime in the future. It also provides a data collection service for the Social Security Administration. An Advanced Record System (ARS) subscriber desiring to deliver a message to an AUTODIN, TWX or TLX subscriber prepares the message with appropriate header information and transmits the message via the CSN to the nearest and/or most readily available Message Switching Center (MSC). The receiving MSC routes the message to the appropriate MSC based on geographical proximity to the exit point from the ARS. The terminating MSC performs all signalling operations required by the foreign network, and delivers the message. A UNIVAC 418 computer, in conjunction with the operational programs, provides users of the ARS with the most sophisticated and diverse services available today to teleprinter terminals in a dedicated communi-

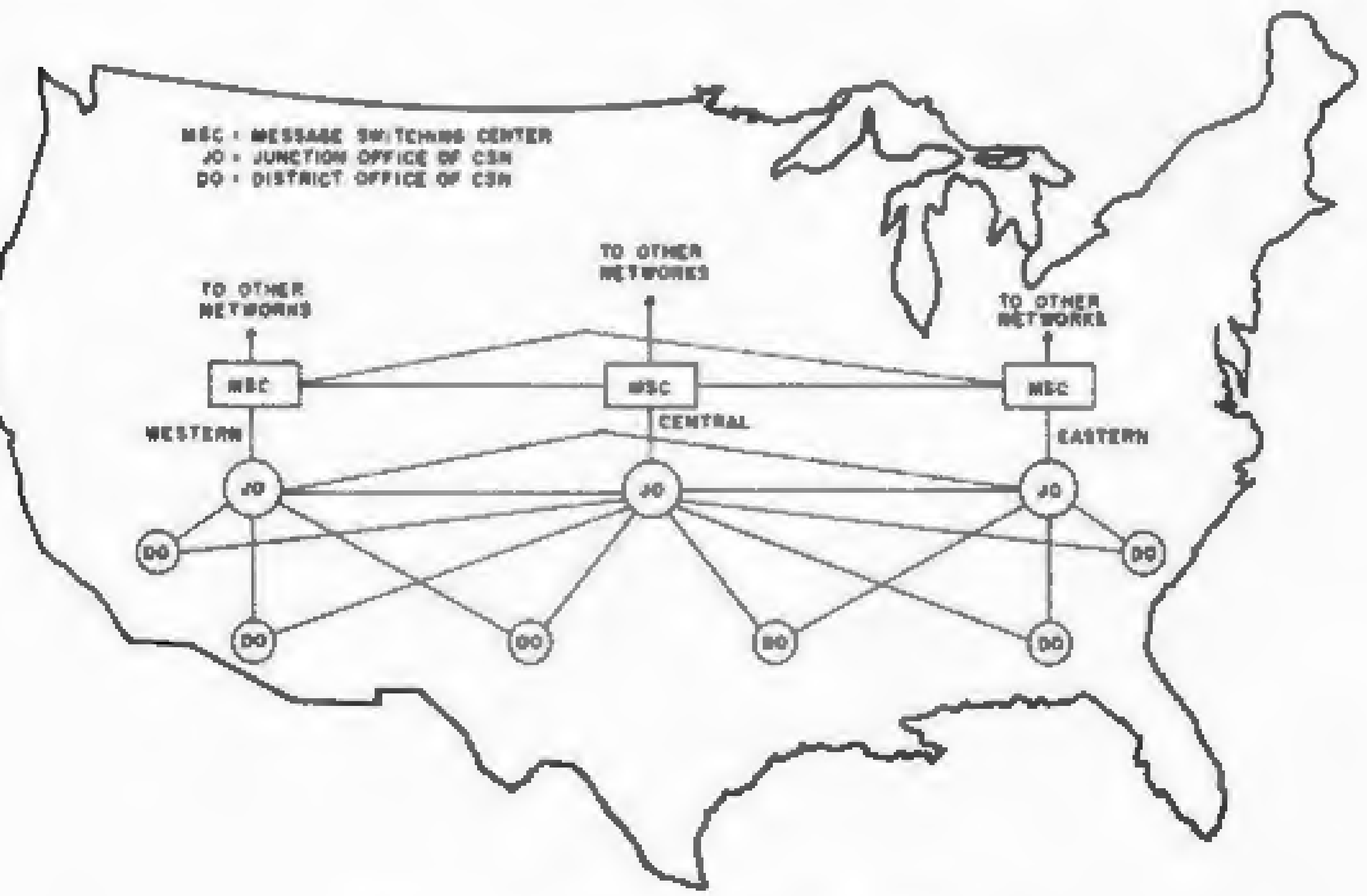

Figure 1. Advanced Record System Network

cations system. Figure 1 is a diagram of the ARS configuration.

The primary subscriber device employed in the ARS is the Teletype Model 33 teleprinter. Teletype Models 35 and 28 are also used but in fewer quantities. The Models 33 and 35 both utilize an ASCII 7 unit code with even parity bit generation in the eighth level. The teleprinter line speed in the ARS is at 100 words per minute.

Services offered

The Message Switching Centers of the ARS offer users the following services, which are unavailable to subscribers in a "pure" circuit switched network:

a) Format verification,
b) Communications between non-compatible subscribers,
c) Multi-message deliveries for one message filed,
d) Book message deliveries for one message filed,
e) Deferred deliveries,
f) Refile of traffic to foreign networks.

Users of store-and-forward services in the ARS must present messages to the MSC in a fixed format. This format includes: start-of-message, classification of the message, precedence of the message, originator's identity, special operating signals, routing information, end of message, etc. The format used in the ARS is based upon the procedures defined in the Joint Army, Navy, Air Force Procedure, JANAP 128A.

MSC Hardware

The hardware components associated with each Message Switching Center consists of:

a) A UNIVAC 418 computer containing 49,152 words of random access core memory,
b) An FH 330 magnetic drum,
c) 5 Uniservo III-C magnetic tape units,
d) A 1004 high speed printer and card reader,
e) An Input/output console typewriter,
f) Front end multiplex equipment with Communication Line Terminals to interface the communication lines.

A block diagram of the MSC hardware configuration is shown in Figure 2.

MSC Software

In order to load and activate the message switching software a "startup program" has been provided which enables the computer operator to load from magnetic tape those programs necessary for the real time message switching functions. This program provides for introduction of parametric information such as Julian date, message sequence number, tape assignments, etc. The "startup program" takes the operator through all the various operations on a step-by-step basis thereby prohibiting the operator from making incorrect or illogical assignments at startup time. When the startup function is complete, the operator is requested to "prime" the system or respond to the program in such a way as to make the operational or message switching program active. As soon as this action is taken by the operator, the communication lines are activated, by program control, thereby enabling an input line to transfer data into the computer.

Due to the nature of the network, message receipt verification is an important aspect of the system philosophy. For this reason pre-message and post-message answer back exchange is utilized on all asynchronous transmission lines in order to verify correct message receipt. If the sender of a message has not received a post-message answer back following dedelivery of his message, he must assume that the message has not been received properly at the destination point. With this philosophy in mind it was decided that the MSC acting as another subscriber in the network must adhere to the same requirements. Therefore, the system has been designed such that a subscriber, transmitting a message to the MSC, must receive from the MSC an acknowledgment following the end-of-message signal. This signal indicates that the MSC has accepted this particular message for store and forward service.

Input Interplay

An input request to the MSC is initiated by the circuit switch which turns the MSC's receive leg of the one way input

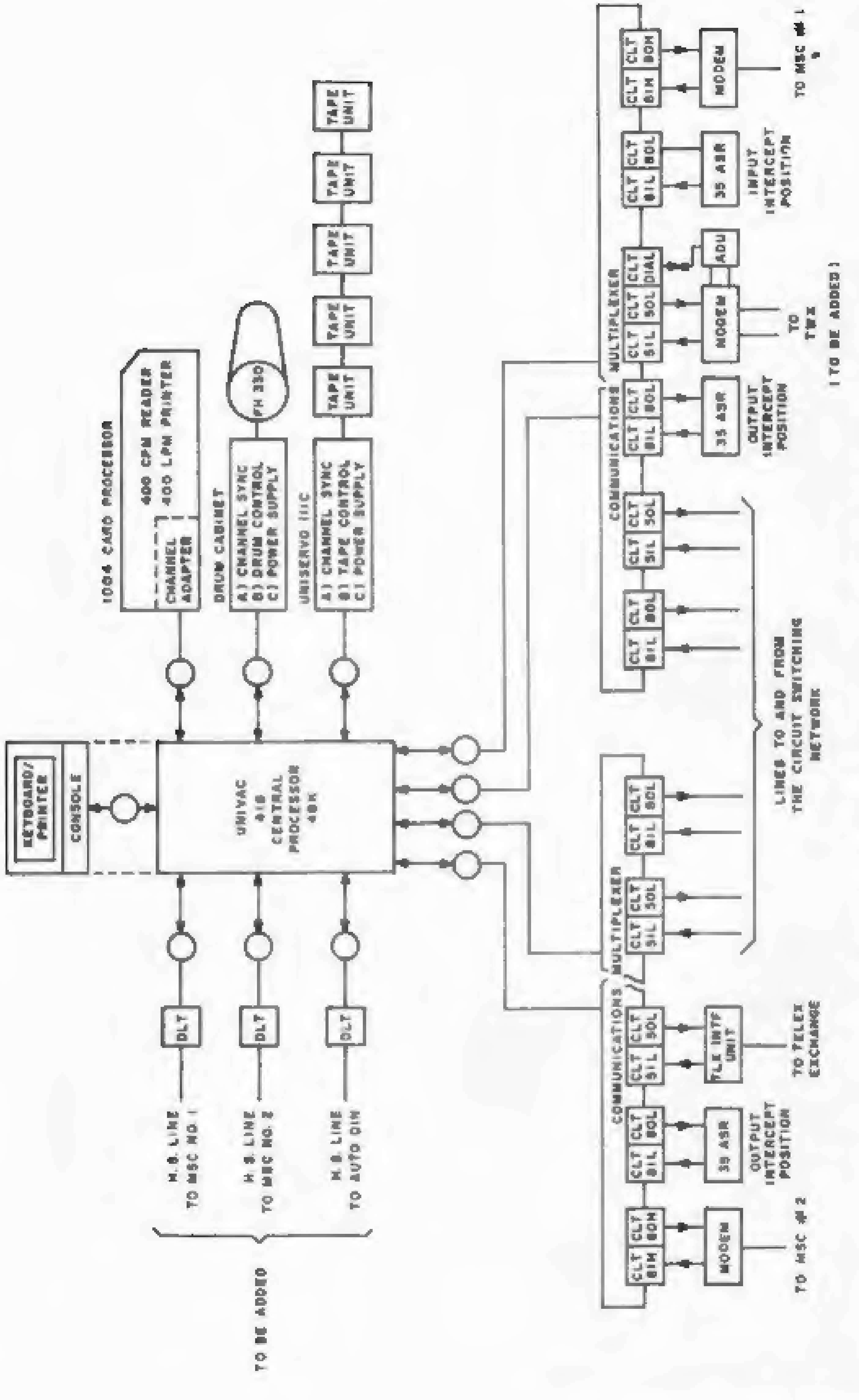

Figure 2 Block Diagram of Message Flow through the MSC

trunk from a spacing condition to a marking condition. Immediately after the leg has gone marking and without any acknowledgment from the MSC the circuit switch transmits to the MSC the last two digits dialed by the subscriber. These two digits identify the MSC. The two characters are placed in a two-character buffer which causes an internal interrupt to the program. The operational program examines the contents of this buffer and if it contains the correct digits, it responds by turning the MSC's send leg on the same input trunk from a spacing to a marking condition. This acknowledgment on the part of the MSC is transmitted by the circuit switch to the originating circuit switch District Office (DO). The originating DO is now informed that the digits which it had forwarded have caused a "subscriber" to be selected and that subscriber is ready to receive an answer back challenge. The originating DO now sends the "Who Are You" (WRU) signal to the MSC.

When the MSC receives the WRU signal, it responds by transmitting its answer back which contains the MSC's dial number by which it was accessed, the unique identification indicating which MSC has been accessed and a 6 digit unique number assigned to this message by the MSC; this is called the Original Message Number (OMN). This answer back is received at two places, 1) the originating DO and 2) the page printer of the originating subscriber. At the originating DO the dial number is compared to verify that the dial number of the connected station is identical to the dial number that was dialed by the originator. If the DO verification is correct the send leg of the originating subscriber is cut through and a complete two-way circuit exists between the originator and the MSC.

Obviously, there are many error conditions which can occur during the input interplay function such as timeouts, incorrect dial numbers received, non-recognition by the message switch of the WRU signal, etc. It is not the intent of this article to describe each and every action taken by the operational program, in the event that any of these error conditions are encountered. However, it should suffice to say that in a real time environment these conditions obviously can and will occur and the message switch has been programmed to anticipate all of the conditions and take appropriate actions such as initiating a disconnect, and printing out to the 1004 high speed printer, an indication of the type of error encountered and the trunk on which it was encountered. If applicable, the OMN is also printed out so that, in the event queries are received at the MSC regarding this particular connection attempt, as much history as possible is provided to the switching center personnel to evaluate the query.

Input Processing

As indicated earlier the MSC, when it has received a complete message and has verified that the format of the message is correct, will deliver to the originator a post-message answer back or acknowledgment that it, the MSC, has accepted the subject message and is now responsible for same. In order to reduce service message handling at the center and to reduce the number of service messages it was decided to deliver in the post-message answer back a rejection notice to the sender if any format error making this message non-switchable had been detected. This requirement being firm it was evident that "real time" or "on the fly" message analysis and processing would have to be performed. It also was apparent that under certain conditions due to the nature of the system and the nature of the requirements the MSC would be required to terminate the connection between the sender and the MSC upon detection of certain types of format errors. Therefore, the following capabilities have been programmed into the operational program, thereby causing a disconnect to be initiated by the MSC:

a) No start of message in the first 24 characters received after a connection is established.

b) No start of message within 20 seconds following connection.

c) An incorrect security sentinel (the MSC at present is programmed to handle only unclassified traffic).

d) A message containing an excess of 7500 characters.

e) An idle input line (20 sec) after Start of Message and prior to End of Message.

f) An input line continuing to transmit traffic following receipt by the MSC of the EOM (End of Message) sequence.

g) Two successive SOM's without intervening EOM.

In the event any of these situations is encountered by the MSC it will initiate a disconnect which at the subscriber terminal end causes the motor of the teleprinter to shut off, thus busting the transmission. At the MSC a printout is delivered to the 1004 high speed printer indicating a disconnect has occurred, the reason for same, the OMN of the message and the header of the message if available.

The second class of message rejection by the MSC is one associated with format errors. Certain types of format errors when detected by the MSC, will be noted in the post message Answer Back sent by the MSC to the sender. This function informs the operator of the error detected thereby enabling the operator to correct and reenter the message. The correction of the message, of course, will be done on an offline basis and another dial up and transmission to the MSC is required. Reasons for this type of message rejection and appropriate, unique identification to the originator, are:

a) Incorrect precedence character.

b) Incorrect adherence to the format requirements.

c) Absence of Start of Routing

d) Absence of End of Routing

e) Absence of "beginning of text" following receipt of a signal in the header indicating that a book message is being received.

f) Absence of any legitimate routing indicators.

If the MSC rejects a message in addition to transmitting the rejection answer back, it also delivers a printout to the 1004 high speed printer indicating the reason for rejection, the OMN of the message, and the header of the rejected message.

If all of the above tests are passed, the MSC will process this message for further delivery. Prior to transmitting the post-message answer back to the originating station the MSC will insure that a reference copy of this message has been placed on the magnetic tape and that an input journal entry for this message has been made. A complete record on magnetic tape for this message must exist before the post-message answer back is transmitted to the originator in order to ensure message recovery in case of a subsequent fault in the MSC. It should be pointed out that this does not mean that the originator must wait after sending end of message for the MSC to accomplish the journalizing of the message, as this journalizing is done in real time as the message enters the MSC. As the MSC receives the message it writes the data on magnetic tape. After the reference copy of this message is complete the input journal for the message is written prior to transmission of the post-message answer back. Once the sender of the message receives the post-message answer back acknowledgment he may assume that the MSC has taken the responsibility for delivering the message.

Internal Processing

As soon as the MSC accepts the pre-message WRU challenge from the sender, the operational program assigns a message control block to the message. This message control block will reside with the message for its entire duration in the system. Contained within this message control block are: 1) the Original Message Number, which is unique for every message that comes into the system, 2) a link address which contains the address of the first segment on the drum on which this message will be written, 3) a word made up of bits identifying the output equipment requirements for this message, i.e., whether it will be delivered to the TELEX network, the circuit switch 8 level trunks, to the circuit switch 5 level trunks, TWX, AUTODIN, to one of the other MSC's, to the MSC intercept position, or the data collection outlet for SSA. A count is also kept in the message control block which contains the

number of deliveries that are required for this message. The message control block is kept in core until the complete message is received. At this time it is placed on the drum and its drum address is placed in the output queue table The queue table which is actually one table containing up to 1024 entries, can be assumed to contain 4 tables, one for each precedence serviced by the system. The four precedences are Routine, Priority, Immediate and Flash The requirements of the system are that the highest precedence messages be outputted first and within each precedence a first in first out basis be maintained. A Flash precedence message, if necessary, will interrupt the transmission of a lower precedence message The MSC holding time associated with each precedence is 60 minutes, 30 minutes, 15 minutes and 30 seconds, respectively. These times are changeable by operator command from the console. The output queue table contains one entry for each message received by the MSC. It is not output oriented from the point of view of quantities of deliveries to be made. For each message received one entry is made in the output queue table. The table entry within each precedence contains the drum address of the message control block associated with the message and the output equipment requirements for effecting all deliveries of the message

Status Conditions

Output deliveries for each message are made via communication facilities and when appropriate, unique hardware associated with these facilities for each output delivery system. Each output delivery system has one or more "trunks" via which a message delivery can be accomplished The trunks making up the output delivery system for each system are referred to as the "output interface" for that system Each output interface can be rerouted by the console operator if deemed necessary due to system conditions. Each interface can be routed to the intercept position for manual handling or to the deferred tape for later transmission. Each interface can be routed to another MSC for delivery by that MSC For instance, the Telex interface at one MSC could be inoperative and for this reason all Telex traffic normally serviced by this MSC can be rerouted and serviced by another MSC. These reroute functions are accomplished by real time operator input at the console of the UNIVAC 418 processor. Illogical reroute conditions are disallowed by the operational program, i e , an interface cannot be rerouted to an interface which is itself being rerouted

Output Processing

A message is selected for output from the output queue table This selection is based upon the output trunk availability for the required output delivery interface and the priority of the message If an interface is rerouted, the output equipment requirements for a message requiring that rerouted delivery interface will be altered The message is selected for output based upon the reroute output delivery interface requirements. This dynamic approach has been provided to enable the current reroute conditions to prevail when the message is actually selected for output. When the message is selected, the control block for that message is read into core from the drum

Output to the CSN

With the message control block in core and at least one trunk available the first data block of the message to be delivered is brought into core from the drum. The routing line of this message is scanned to find the routing indicator for which this selection was made. This process is required because the message may contain routing indicators for delivery by other outputs, i.e., an output other than the CSN. However, the CSN equipment requirement was indicated and therefore at least one routing indicator serviced by the CSN will be in the routing line. When this routing indicator is found, a mathematical process is performed on the characters of the routing indicator, yielding a drum address. This drum address contains the CSN dial number of this routing indicator When the dial number is read from the

drum, it is given to the output interplay program. The output interplay program requests service from the CSN by causing the send leg of an output trunk to change from spacing to marking. This action causes a request for a register from the CSN. When the circuit switch attaches a register, an appropriate signal is given to the MSC. The MSC, recognizing this signal, proceeds to deliver via its send leg 5 digits. These five digits define the station whose routing indicator appeared in the routing line of the message. When the station is seized by the CSN, a call connect signal in the form of two digits is transmitted to the MSC by the CSN. These two digits are sent on the receive leg of the same output trunk. The message switch, after recognizing the two digits, transmits a WRU signal to the station in order to verify that the correct station has been connected. The station upon receiving the WRU signal will automatically have its answer back tripped off, thereby transmitting back to the MSC the contents of its answer back which includes its five character dial code. The MSC compares the five digits received with the five digits dialed and, if correct, commences transmission of the message. Obviously, once again, there are numerous error conditions that can and do occur during output interplay; these are all anticipated by the operational program and appropriate high speed printer deliveries are made when they occur.

Message delivery is accomplished utilizing routing line segregation. The operational output program will deliver to this recipient, between the start of routing and end of routing, only the routing indicator associated with this delivery. Further, if the message was a book message delivery which requires text addressee segregation the operational output program will deliver only the appropriate TO and/or INFO lines which contain the same routing indicator as that to which this message is being delivered. As the blocks of information are transferred from core to the output line additional blocks, that are linked for this message, are brought in from the drum. When the last block associated with this message is delivered, output processing is flagged to look for end of message. When it transmits the end of message it will generate a WRU signal. Once again this will cause the outstation answer back to be activated and the MSC will compare the dial digits contained in this answer back with those that were used to dial the station. If the comparison is correct, the message is considered successfully delivered. An output journal indicating the message number, the routing indicator and dial number to which the delivery was made and other pertinent information is created. In the event no response or an incorrect response is received to the Who Are You signal, the MSC will try two more times on this connection to solicit the answer back response. If it is still unsuccessful, it will disconnect and redial. Upon successful completion of this second dial attempt it will make another delivery of the message under Suspected Duplicate (SUSDUPE) conditions.

If another CSN trunk becomes available during the transmission of a message, analysis is performed on the queue table and the message control blocks that are resident in core for those messages which are actively in the process of being transmitted. This analysis will yield a result enabling a second trunk to be seized by this same message control block if additional CSN deliveries are required for this particular message.

If a busy is encountered in an attempt to connect to a station, the output interface requirements are removed from the queue entry and placed into the CSN busy table. It will remain in the busy table for a minimum of 45 seconds unless the number of entries in the busy table exceeds 100, in which case it will be removed from the busy table and placed back into the queue table. During a message's residence in the CSN busy table no circuit switch selections for this message will be attempted. However, other deliveries for other output equipments can be initiated. When all CSN deliveries associated with this message have been accomplished, the CSN equipment requirement bit in the output queue is erased. As each delivery is effected a count is kept, thereby accumulating the total number of deliveries made for this

message. If all CSN deliveries are complete and no other equipment requirements exist for this message, the message itself is ready for terminal testing. These tests will verify that all message deliveries that were required at input have in fact been made at output. A comparison of the messages delivered count is made with the delivery requirement count, the latter calculated at input time. If there is a discrepancy in the two counts, a printout is delivered to the console indicating the magnitude of the discrepancy and the OMN of the message. Terminal testing will also verify that no intercept deliveries are required due to error conditions being encountered in output. When all terminal tests have been performed, the message is released from queue and the drum segments associated with this message are returned to the drum availability table.

Delivery to Another MSC

The structure of the routing indicators that are utilized in the ARS easily enable detection of the responsible MSC for a given routing indicator. The third and fourth characters of each routing indicator define which of the three MSCs have primary responsibility for that particular station. At input time the routing indicators are examined and the appropriate routing with respect to the MSCs is performed. When output processing selects a message for delivery and this message has output requirements associated with another MSC, transmission to that other MSC is accomplished via a dedicated 2400 baud full duplex facility. At present this transmission is being performed with a Communications Line Terminal (CLT) through the multiplexer but it is anticipated that this interface with the 418 will be modified to incorporate special purpose hardware called a UNIVAC Data Line Terminal (DLT). The present operation enables 2400 baud transmission to take place with block parity and character parity being generated and checked. It also is under software control with respect to number of characters per block; the size of the block chosen is equal to a drum block, 32 computer words. When the output processing program selects a message which has delivery requirements for another MSC, the same procedure for the CSN as indicated above is followed. The entire routing line of the original message is transmitted in one delivery. Additional data is transmitted associated with each routing indicator to be serviced by the receiving MSC; this data is transmitted by means of a message dial header (MDH). There is one MDH for each routing indicator to be serviced by the receiving MSC. This MDH will contain information such as the address on the drum of the dial number associated with the routing indicator, thereby performing some of the output processing requirements for the receiving MSC. The MDH's are transmitted in blocks following the message control block and preceding the first data block. When the final block of the message is delivered to the receiving MSC, acknowledgment of this block must be received by the originating MSC prior to the writing of the output journals. Likewise the receiving MSC must make input journals prior to acknowledging receipt of this message. Once these journals are written the routing indicators associated with the delivery are no longer the responsibility of the local MSC but are the responsibility of the receiving MSC. As soon as this message has been delivered the appropriate queue entry is erased in the queue table. Once again, if this is the last equipment requirement associated with this message the message will be subjected to terminal testing as indicated previously.

Transmission to Telex

Interface to the Telex network is accomplished by using the Western Union Telex Interface Unit 12150-A with the 32 KSR set. This device translates the Baudot characters (dial number) presented to it by the MSC program to 60-40 dial pulses required by the Telex exchange. Once it signals the MSC that a connection has been established it cuts the MSC send leg and receive leg through to the Telex connected station. The MSC delivers a WRU signal, FIGS D, to the connected station. The connected station transmits its answer back

but in this case the answer back contains the directory mnemonic for the station. This directory mnemonic must be contained in the routing line of the original message that was received by the MSC as it is used to validate the received answer back. If this comparison is correct transmission takes place at Telex speed and code. If the comparison is incorrect, a disconnect is initiated by the MSC and a retry is attempted. Following a successful connection the message is transmitted and a post-message answer back is solicited by the MSC. If this post-message answer back is correct, a disconnect is initiated and journals are updated accordingly. If this particular delivery was the last Telex delivery requirement for a particular message in the queue table the Telex equipment requirement bit is erased from the queue table. If this is the last or only equipment bit in the queue table, its erasure will then cause terminal testing to be initiated. Obviously a Telex station can be busy when an attempt to connect is made. In this event the message will go into the Telex busy table and not be selected again for Telex output processing until it emerges from the busy table. The time that it stays in the busy table for Telex delivery is three minutes.

High Speed Subscriber Output

One of the users of the ARS has unique communication requirements. This user, Social Security Administration (SSA) has approximately 700 stations who wish to communicate with a Data Processing Center at the SSA Headquarters in Baltimore. The input media to the computer in Baltimore is magnetic tape. The ARS MSC's are used to accumulate the traffic from the 700 SSA stations and generate a magnetic tape. This magnetic tape is in the code and format necessary for the SSA activity in Baltimore. The SSA outstations dial an MSC and, when connected, deliver the message with the Baltimore Social Security unique routing indicator in the routing line. This routing indicator is recognized by input processing and an appropriate bit in the output queue table is marked. This bit is identified as the High Speed Subscriber (HSS) bit. When output processing recognizes this bit as being marked, a unique program is activated. This program delivers the message to a dedicated Uniservo at the 418 performing code and format conversion. The traffic is accumulated on this dedicated Uniservo and periodically an off-line, non-MSC, tape-to-tape magnetic tape transmission takes place between the MSC site and the Baltimore site. Due to the characteristics of the traffic that is being transmitted by the SSA, i.e., data rather than narrative, certain safeguards were incorporated into the operational program. These safeguards, suggested by the Government, enable the operational program at input time to detect incorrect parity in the text of a message that is to be delivered to the SSA Baltimore Data Processing Center. When such a parity error is detected, the MSC will disconnect thereby causing transmission to stop from the outstation. The outstation will re-attempt transmission on the assumption that the parity error disconnect was caused by a "line hit". If another disconnect is realized the operator takes action dictated by the circumstances, namely, recutting of the message or maintenance call-out. The result of this mode of operation for the Social Security Administration indicates a very high degree of error-free traffic being processed in the Baltimore Computer Center.

Ancillary Functions

In addition to the main line operational programs which have been discussed above, there are numerous support programs which have been incorporated to aid in the operation of this system. Intercept of traffic in the ARS has been developed with a key requirement for ease of operation on the part of the intercept operator. All traffic presented to this service position has appropriate tags associated with it to identify the particular routing indicators for which the delivery to service is being made and the reason why this delivery is being made. In addition to the intercept processing a definite real time feature of this system is its ability to search and retrieve traffic. At the operator's op-

tion a REIO Journal (the journal containing the reference, input, output, and error entries) can be searched under operator specified parameters. A Reference Journal may be searched under the parameters of

a) Original Message Number (OMN)
b) Originator's Routing Indicator
c) Destination's Routing Indicator
d) Filing time
e) Any combination of b, c and d above.

The operator, in performing the reference journal search, specifies the appropriate parameters and indicates whether the program should make the delivery of the retrieved message to the high speed printer or to the output intercept position, a 35 ASR set. The operational program will indicate whether this particular message was accepted by the MSC for delivery; an acceptance indicator is transmitted with the retrieved message. The operator may search the REIO journal for an output journal entry. This search is based upon the OMN.

By means of the console an operator can set an interface or a given station to the deferred state. Under these conditions any and all traffic that is to be transmitted to those interfaces and or stations will be intercepted and transmitted to the deferred tape. Each time a message is written on the deferred tape a printout is delivered to the high speed printer indicating the OMN of the message, the precedence of the message and the routing indicator of the station that is being deferred or the interface being deferred. When the status of a station or interface is changed from deferred to up or to a reroute condition, the operational program tells the operator whether there are any messages associated with this station or interface on deferred tape, thereby advising the operator of the need for a deferred tape search. The processing associated with the deferred tape search is to examine each message on the deferred tape. If the status conditions associated with the delivery requirements for this message are still deferred, the message is rewritten on a new deferred tape. If the status conditions indicate that the recipient of this message is no longer deferred, the message is brought back into the system and placed in the output queue table.

Recovery Procedures

In any application of a store and forward communications system, one of the most important aspects of the system is its ability not to lose messages. This requirement was fundamental in the design of the operational programs of the ARS as well as the recovery programs. For this reason two independent means of recovery are provided in the ARS. They are tape recovery and drum recovery. The choice of which recovery procedure to use is based upon the characteristics of the failure, i.e., availability of the drum, tape drives, tape synchronizer, etc. A fundamental requirement of recovery is to recreate as accurately as is possible the environment which existed prior to the failure. The ARS recovery subsystem assumes that once a failure has occurred whether it be hardware or software the dynamic information and tables in core are no longer valid or available. Therefore, the only information available to the recovery subsystems is that which is on magnetic tape or drum.

Once the problem associated with the cause of the malfunction has been corrected a recovery run is performed.

Tape Recovery

The function of tape recovery is to examine all the input journal entries and all the output journal entries that have been created since the previous startup. These journals are balanced thereby enabling the recovery program to identify those messages that were resident within the system at the time of failure. Two passes of the REIO journal are required. In the first pass a ledger is kept enabling input journal entries and output journal entries to be compared and where applicable to cross off all those input journal entries which have in fact been satisfied by output deliveries. At the end of the first pass a list is generated, this list, being kept in core, contains the number of the messages (OMN) which have in fact come into the MSC but have not been delivered. During the second pass in which an actual recovery tape is generated the listed messages are retrieved from the reference journal and placed onto the recovery tape to be

presentd to the operational program at startover time. All such messages that are recovered are marked for suspected duplicate deliveries as no provisions are made for keeping a record of those messages that were in the process of being transmitted at the time of the failure

Drum Recovery

Drum recovery assumes that for some resaon the tapes or more specifically the REIO journal is not available to the recovery subsystem. In this event the drum is examined for all in-transit message blocks that are completely linked but have not been made available to in-transit storage Any complete messages on the drum will be recovered by drum recovery and written on a recovery tape. This recovery tape with appropriate SUSDUPE tags will be presented to the operational program at the next startover time

Overload Considerations

In any store and forward computerized switching environment a point can be reached in which no more storage is available. This point of course differs for each system depending upon the economics of the system and the characteristics of the traffic. The ARS has such a point and it can be reached from two directions, (1) no more output queue table entry positions available, and (2) no more in-transit (drum) storage available. When overload is reached in the ARS, by program control all non-seized input trunks are put into the busy state. No more input seizures can be accommodated. Similarly, transmission from dedicated trunks is not acknowledged. This point is called the upper threshold In the event the storage capacity of the MSC cannot accommodate those messages that were in the process of being received when the upper threshold point was reached, the MSC will reach the saturation threshold At this point all CSN inputs that are active will be disconnected and remain in an unseizable condition. If the system has reached upper threshold, all input trunks become unavailable as message transmission ceases on these trunks This condition is called shut input trunks (SIT) and is entered by program control It can also be entered by console command enabling the operator to refuse input traffic. This feature is provided for the "drying up" of an MSC, allowing maintenance or off line processing to be performed during non peak traffic conditions. Assuming the SIT condition was reached because of overload, the system will remain in SIT until the lower threshold is reached. When this point is reached, input will open up immediately and any and all calls addressed to this MSC will be serviced. It is possible that a flip flop condition between open input trunks and close input trunks can be experienced However, based upon the traffic volumes which the ARS is presently handling and the efficiency of the output processing, the overload condition has not presented any operational problems

Management Reports

In addition to the off line recovery programs which have been provided for the ARS, a category of off-line programs called Management Reports have been developed. These programs enable GSA to generate management information necessary for the day to day operation of the Advanced Record System These reports which utilize the journal information enable statistical studies to be made with respect to the characteristics of the users of the system, the type of errors and the frequency of errors being experienced in the system and the traffic volumes being handled by the system. The journal information is augmented on a twice a month basis by transmission reports to the MSC from the District Offices. These reports, prepared in ARS format, contain meter usage information. The meter usage information is a measurement of the total amount of traffic originated by a subscriber. This meter usage information is processed in order to determine each subscriber's usage of the ARS for a given period of time, combining the MSC usage factors with the CSN usage factors. From this processed report billing information is made available to GSA

Summary

In a short period of time the three Message Switching Centers which are in operation today will be augmented by software providing the capability of interchanging traffic with three AUTODIN centers and with the TWX network. In addition to these capabilities, improvements in the present operational program will be incorporated. These improvements are based upon needs that can only be envisioned once a system is in operation and performing on a day-to-day basis. Such improvements are in the area of tape error handling and peripheral error handling procedures.

For the first time Western Union and GSA are providing users the advantages of a Circuit Switched Network and a Message Switched Network in one system, the Advanced Record system. This marriage has provided the best features of both. The message switch of the ARS is now handling over 50 percent of all traffic transferred in the network and as the situation dictates additional narrowband trunks can be accommodated to handle additional traffic. Also, as the requirements of the Government become more sophisticated the appropriate MSC modifications and additions can be accomplished so that a continued growth of the message switching capability can be provided to the Government

Acknowledgment

The author wishes to express sincere appreciation to Mr. V. C. Kempf and to the ARS Computer Systems Engineering group, for their dedicated effort in the implementation of the MSC's into the ARS

ROBERT H. LEONARD, Project Manager, Advanced Projects in the Information Systems and Services Department, is responsible for the design, development and implementation of government systems. He is presently directing the Western Union effort in the implementation of a computerized system for the Department of Defense

Mr Leonard first joined Western Union in 1956 and was assigned to the EDIT system After assisting in the Plan 57 Switching Center development he was promoted to Senior Project Engineer and made responsible for the design and implementation of the Air Force Bomb Alarm System.

In 1961 Mr Leonard joined the International Telephone and Telegraph Company, Data Information System Division, where he was associated with data display for the Air Force SAC 465L project and the ITT NASA project team.

Mr. Leonard rejoined Western Union in 1963 and was assigned to the General Services Administration's Advanced Record System. In this capacity he was responsible for the computer systems design, software development, and computer/programming acceptance tests. In September 1965 Mr Leonard became Project Manager GSA/ARS, responsible for the entire technical effort of all aspects of the Advanced Record System. In August 1966 he became Project Manager, Advanced Projects.

Mr Leonard received his B.S. degree in Engineering from the Newark College of Engineering in 1956. He attended graduate school at New York University. He holds two patents.

*international telex service through computerized line switching**

Peter J. Klein

Western Union International, Inc.**

Editorial Note Western Union connects to three international Telex carriers, thus providing Telex connections to all parts of the world. These international carriers are ITT World Communications, RCA Communications Inc., and Western Union International, Inc

Western Union International, Inc. (WUI) is one of the principal U S. common carriers providing International Telex Service between subscribers in the United States and overseas countries, WUI operates its own Telex network for international subscribers in New York, Washington, San Francisco and Hawaii This network is also interconnected in New York, one of four gateway cities, with the Western Union Telegraph Company's Telex network and AT&T's TWX system. This service enables WUI Telex customers in the four U S gateway cities, as well as subscribers of the two domestic networks, to establish direct subscriber-to-subscriber teleprinter connections within a few seconds to correspondents throughout the world

Over the past years, international Telex has had a greater impact on global business transactions than any other form of communications. It eliminates the language barrier inherent in international telephone conversations and provides an instantaneous information record to the caller and to the overseas recipient. This paper describes the new computerized Telex system which has been recently installed in WUI's New York gateway office as a major step in the automation of its worldwide Telex service. Such an application of a digital computer system for automatic switching of international Telex calls is the first of its kind

In the early stages of international Telex operation, when automatic switching equipment had not yet been introduced in the gateway cities of the common carriers all connections were established through manual operating positions. As more and more foreign administrations participated in the direct interconnection with U S. carriers, full compatibility between the domestic network and overseas systems became a prerequisite for fast and reliable international Telex service For some time, operators in the gateway cities were to assume the task of adapting switching and signalling requirements of the calling system to those inherent in the called network.

With gradual transition from manual to semi-automatic and then to fully-automatic operation, it soon became obvious that electro-mechanical Telex exchange systems, which were already widely used in

*Presented as IEEE Conference Paper No. 19CP66 1337 at the National Electronics Conference. Chicago Illinois October 3 1966. under the sponsorship of the Data Communication and Telegraph Systems Committee of the IEEE Group on Communication Technology.

**Western Union International is not affiliated with Western Union Telegraph Company.

national networks for more than a quarter of a century, did not provide adequate flexibility for fully-automatic international service. Western Union International foresaw the need for greater operating capability in this area and introduced, early in 1965, direct subscriber-to-subscriber international Telex service as an interim step in its long range modernization program. This advance towards automation was only possible after extensive equipment modifications were made in the existing Telex exchange.

Now after several years of planning, WUI has, in service, a fully-automatic computerized Telex circuit switching system which is integrated into the New York Telex exchange as an on-line real time switcher. The center provides (1) a number of special service features to U.S. subscribers which would be most difficult to perform with electro-mechanical systems, (2) utmost operating capability and flexibility in switching international calls to overseas administrations. Its special features are:

- Automatic alternate trunk routing, thus reducing the number of "circuit busies" and making more efficient use of the international trunk lines.
- Automatic transit routing.
- When requested to do so, the system will automatically provide the chargeable international time on calls originated by U.S. subscribers.
- Abbreviated address dialing — automatic selection, using three alpha characters which the computer decodes into meaningful digit combinations.
- The system provides, automatically, the subscribers with the capability to charge calls to more than one account number.
- The Center enables TWX subscribers —both 60-WPM and 100 WPM stations—to make fully-automatic international calls.
- The system regenerates teleprinter signals in both directions on calls originated by U.S. subscribers.
- The system interfaces trunk lines to overseas networks which operate with type A or type B signalling, including to systems employing variations of the two principal signalling modes.

To further apprise the reader of the two types of signaling systems used in international trunk circuits the following can be said about the two CCITT recognized modes. Type A is usually associated with the teleprinter keyboard method of selection, and type B, as a general rule, is used with number plate dialing. A third type of signalling system, primarily intended for automatic transiting of international Telex calls through intermediate countries has been recently introduced and designated as type C signalling. The C system provides for the interchange of alpha characters over international trunk lines whereas A and B modes relate to the polarity and timing intervals of call progress signals over the forward and backward telegraph transmission paths.

International Gateway Exchange

WUI has centralized its international Telex operation in the New York gateway center which consists of a large transit exchange and a computer system. Figure 1 illustrates the overall network layout. The computerized section of the gateway center consists of two Control Data general purpose digital computers, Type 160-G. In this application, one computer as a principal switching link processes all international calls originated by U.S. Telex subscribers. All inbound connections, i.e. Telex calls from overseas to U.S. subscribers, with one exception, are switched directly by way of the regular TWM Telex exchange and are not routed through the computer. The exception being that inbound TWX connections are transited by the Telex exchange to the computer, which completes the call and performs the required code and speed conversion. A standby computer with identical on-line performance capabilities is used for EDP (Electronic Data Processing) functions, such as Telex billing, payroll, accounting, statistics. A simplified comparison between the electro-mechanical exchange and the computerized system is shown in Figures 2 and 3.

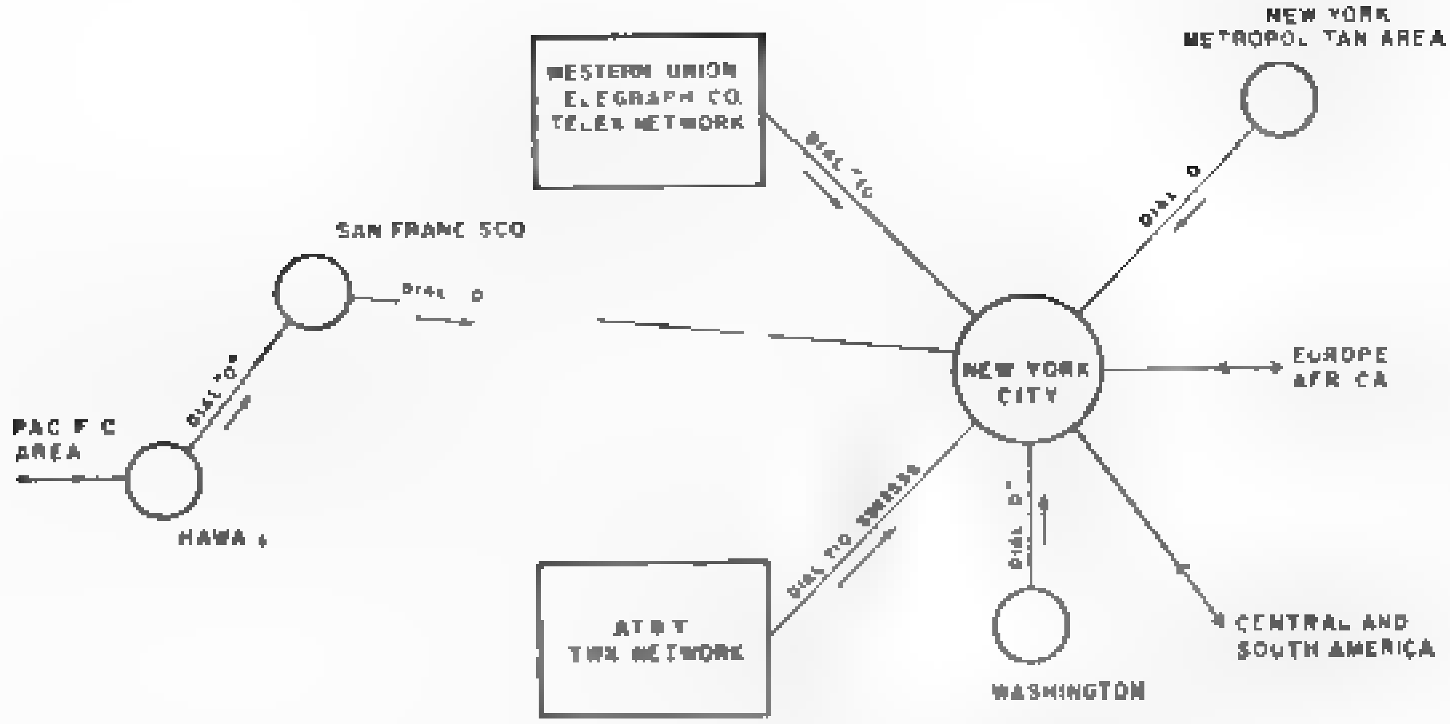

Figure 1. Western Union International Telex Network

The new system consists of several hundred specially designed trunk terminating units (TTU) which provide an interface with the inherent signalling and data transfer modes of the digital computer, several magnetic tape units for storage of billing data, and a magnetic disk file accommodating the decoding program for abbreviated address selection. The primary switching and billing program consists of some 5000 instructions stored as a permanent record in the core memory of the on line switcher and is also held available on the peripheral magnetic disk for instantaneous transfer to the standby computer. The memory section of each computer consists of basic memory modules and has a storage capacity of 24,576 computer words. This capacity can readily be expanded to 32,768 words by means of an additional 8,192 word module for each computer. The storage read/write cycle of 1 35 microseconds and a mean instruction carry-out time of 3.0 microseconds are typical characteristics of the Control Data 160-G computer.

In order to service all trunk lines within the time interval of a character length, interrupts occur at 45 milliseconds. During each 45 ms period one half of all 110 baud TWX lines and one third of all 50 baud Telex lines are scanned by the computer. A given TWX trunk will hence be in communication with the computer every 90 ms, coinciding with the rest pulse of the ASCII character, and a given Telex trunk will be serviced every 135 ms, coincident with the rest pulse of the CCITT 5-level character. The programmed routines to execute switching and billing functions can be classified into three types (1) line scanning, input data, status reports and data transfers to the memory are designated as A routines, (2) programs which perform real-time work on a character by character basis are called B routines and (3) programs which carry out non-real-time operations are referred to as C routines. A and B routines cannot be interrupted since controlling events on input/output lines demand timely precise execution; C routines can extend over several interrupt cycles.

Trunk Terminating Unit (TTU)

The TTU interfaces the Telex trunk line with the computer by way of a two-stage multiplexer and consists basically of an input module to terminate the receive path and an output module to control the send path. The input unit of the TTU (1) interprets a call request from the trunk and conveys this condition to the computer, (2) receives teleprinter signals in start stop

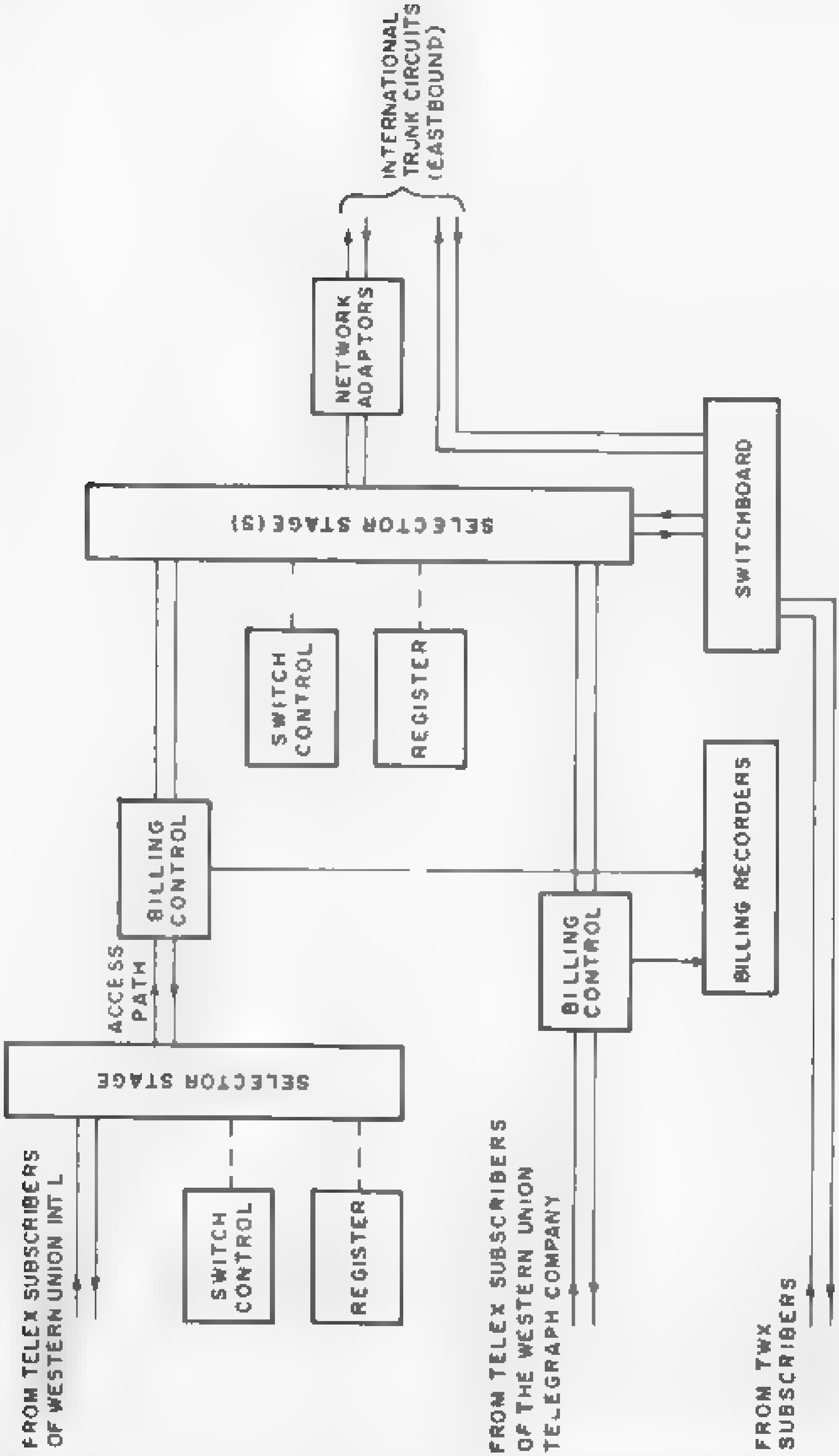

Figure 2. Electro-Mechanical Telex System

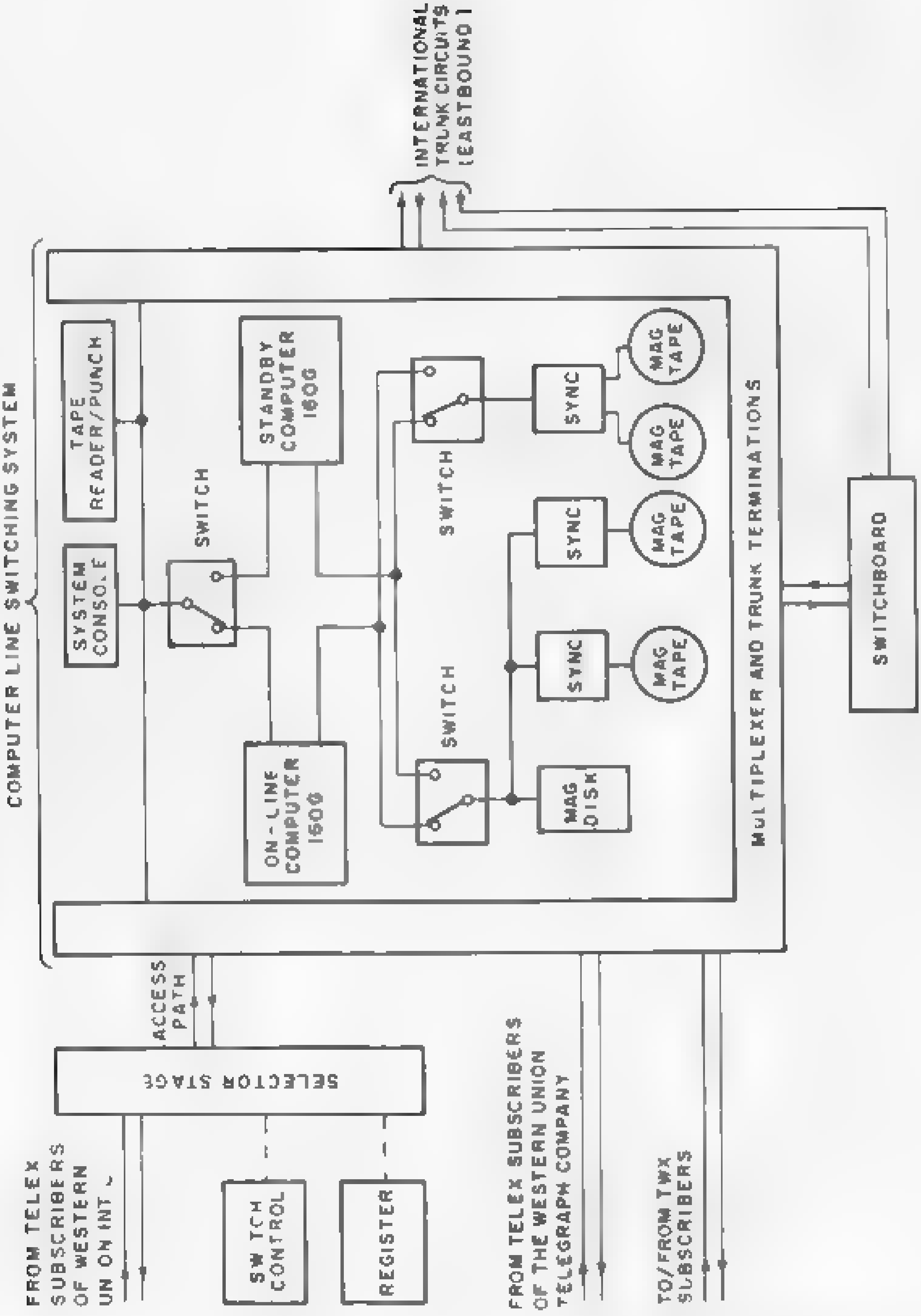

Figure 3. Integrated Computer Telex System

Baudot code serially, (3) removes the start and stop pulses from each character, (4) distributes the five data bits into an intermediate assembly register and (5) informs the computer by way of the input multiplexer that a character is ready. When the computer selects this input unit via master multiplexer and input multiplexer, it accepts the character from the holding platform, transfers the five data bits to a specific location in the core memory and returns an input acknowledgement signal to the TTU. This signal will clear the "character ready" bit. The subsequent character to arrive in the assembly register will cancel the previously held data bits.

The output unit of the TTU carries out the following operations (1) issues the call connect signal to the calling exchange or (2) when interfacing a trunk to an overseas network, it extends the calling signal over the forward path, (3) receives five data bits in parallel form from the computer via the master multiplexer and the output multiplexer, (4) transfers the character from the holding register to the output register and clears the former, (5) sends out serial bits to the trunk line adding start and rest pulses, and (6) requests the next character for the holding register by issuing a "character request" signal to the computer.

Line Multiplexer

The operation of this equipment can best be explained by comparing the multiplexer with an electronic selector switch which connects, one at a time, all of the trunk lines in a full-duplex mode to the computer. The multiplexer thus regulates the data exchange between the input/output modules of the TTUs and the computer. It is composed of a master multiplexer, two input slave multiplexers and two output slave multiplexers for every 16 Telex trunks and/or 8 TWX lines. The multiplexer responds to read, write and connect commands from the computer, and initiates a channel interrupt signal which periodically asks the computer to enter input/output routines.

In the read mode, the computer connects a master multiplexer in order to scan a group of Telex or TWX input modules for data transfer and the output modules for "character request" status. In the write mode, the computer connects via the multiplexer each output module for which there is data waiting. Specific connect codes composed of four digits in octal code are used by the computer to address an individual TTU within a multiplexer cabinet. The first and second digit determine which group of four multiplexer cabinets to communicate with. The third digit selects the cabinet as well as the top or bottom group of TTUs, and the fourth digit designates the specific TTU, both its input and output modules. Each multiplexer cabinet is equipped with a decoder plug to unpack the first three digits of the address, whereas the last digit is interpreted by the internal logic of the multiplexer. Fig. 4 shows the data flow within the computer system.

Trunk Line Dialers

Whereas all dial information sent from call-originating subscribers in the USA is presented to the computer in form of Baudot or ASCII code keyboard signals, many overseas networks require number plate dial pulses for setting up a connection. The computer recognizes these object countries by the three-digit international area code which precedes the subscriber number of the called station. Upon seizure of an international trunk circuit connecting to a network with type B signalling and number plate dialing, the computer assigns an electronic dialer to this trunk line. A common pool of 16 dialers services up to 64 international trunks. Each of the dialers has access to each of the 64 lines by way of a crossbar switch. The computer will allot all dialers in sequential order to the trunk circuits and thus provide for equal load distribution. A dialer becomes associated with an outgoing trunk line only for the duration of the computer controlled selection phase and is thereafter immediately available for other calls.

Trunk Line Configurations

Upon detection of format deviations and a number of other abnormal conditions,

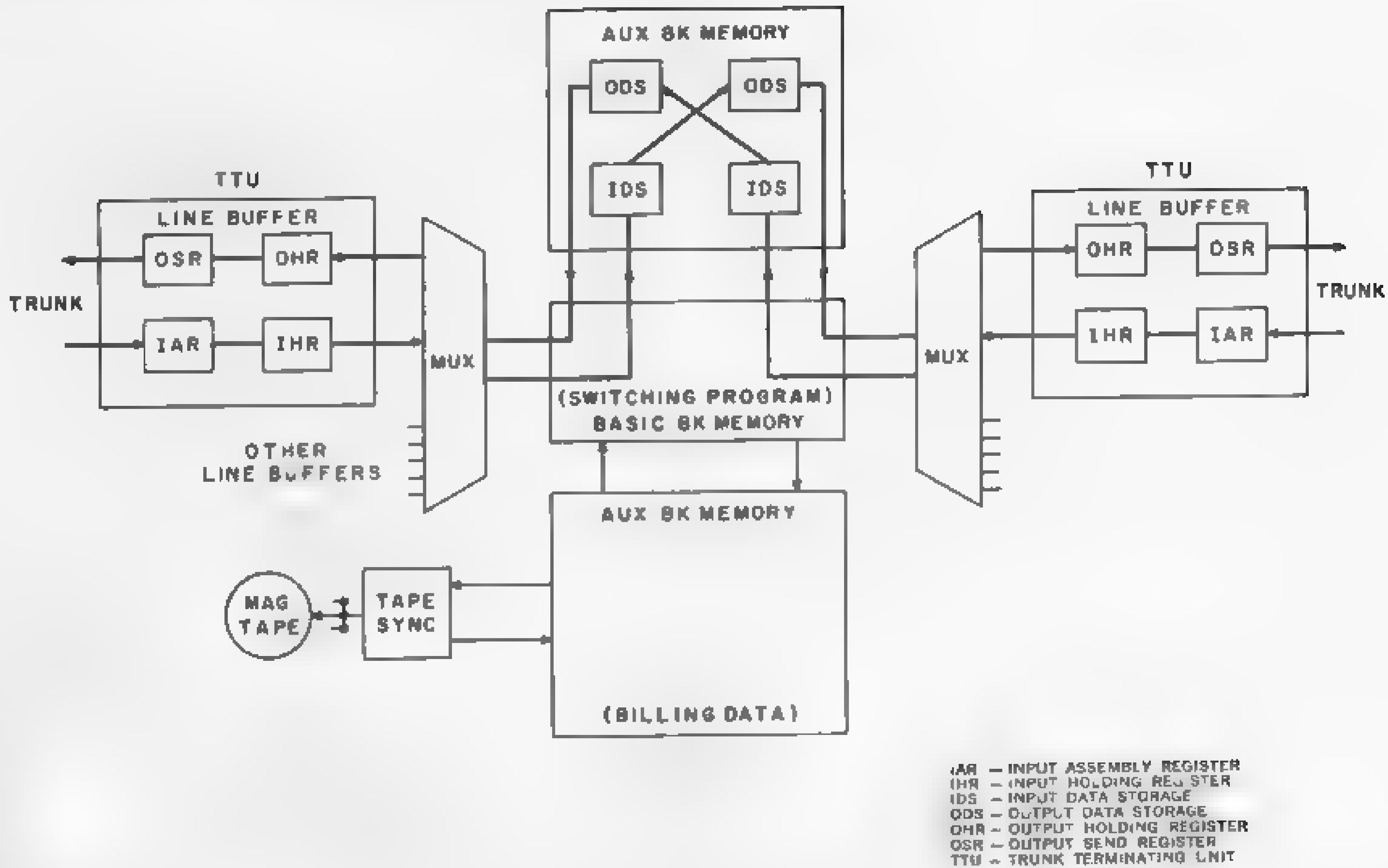

Figure 4. Data Flow Through the Computer Center

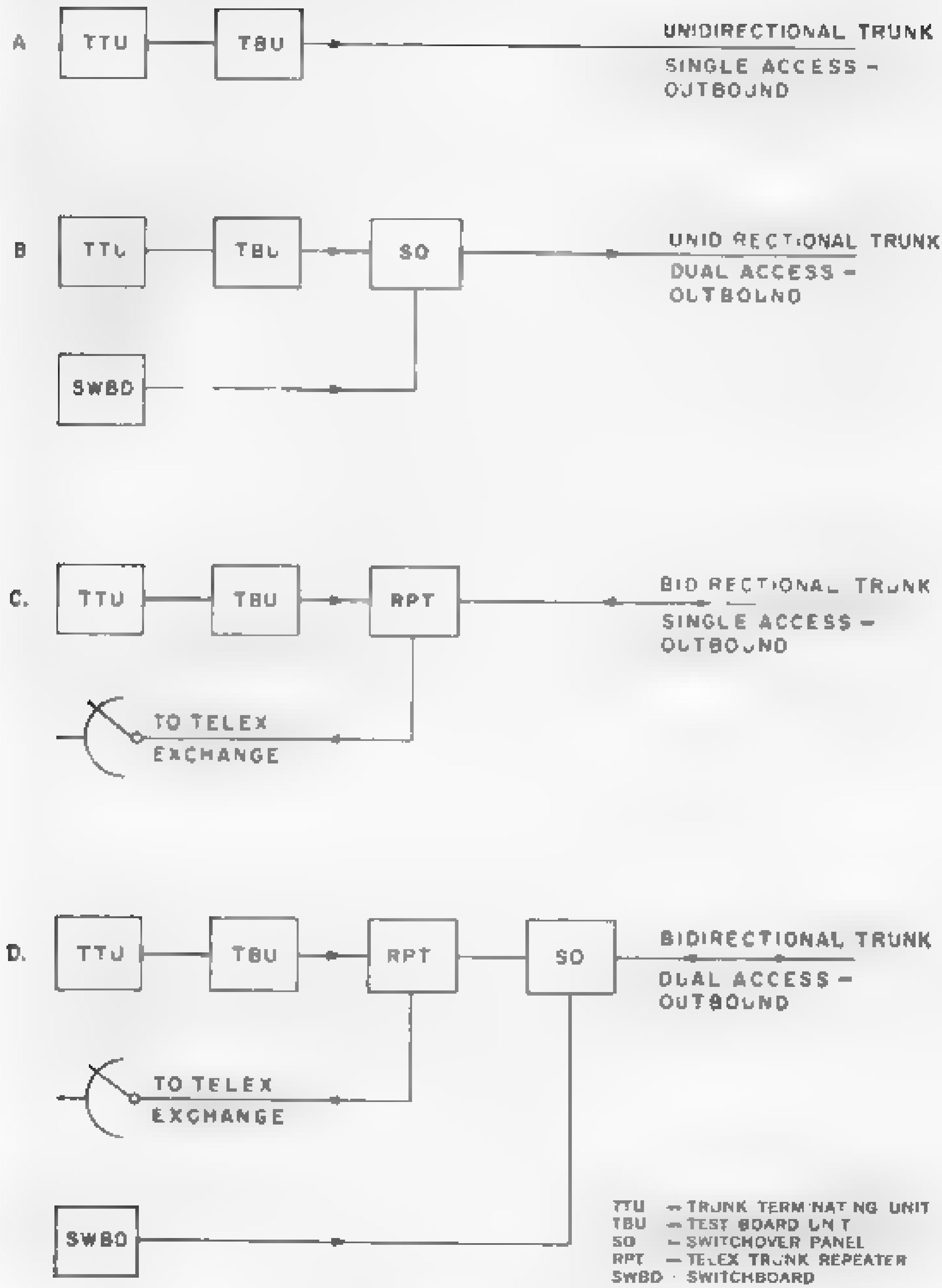

Figure 5. Computer Output—Trunk Configurations

the computer routes the call to a manual switchboard for operator assistance. Specific flag characters indicate the reason for routing the call to the switchboard. The operator then establishes the international connection through the switchboard

To provide the computer and the switchboard with mutual access to international trunks, and at the same time operate some of these trunks as bidirectional circuits, several different trunk configurations have been chosen to service the various sources of Telex calls as shown in Fig. 5. This arrangement provides for optimum efficiency of international telegraph channels.

Call Procedure and Format

When the U.S. subscriber dials the access code from his teleprinter subscriber position, a connection path is set up to WUI's New York computerized Telex center The computer then issues a call-connect signal, turns on the teleprinter motor of the calling station and immediately sends a sequence of service codes to acknowledge the call request. This text contains a one-digit network designation, a four-digit message sequence number, time, date and an answerback code identifying Western Union International.

After the identification of the caller, (answer-back from Western Union Telegraph and WUI subscribers or printed TWX station number), the subscriber follows a selection format already introduced with the implementation of WUI's interim automatic Telex service in 1965. The caller types on his teleprinter keyboard the area code of the called network and the overseas subscriber number followed by the end-of-selection signal (+) plus sign or a quotation mark ("). If he wishes to have the Telex bill for a call charged to a special account number, he may indicate this by typing a two-digit number combination immediately after the plus sign.

The computer recognizes the end-of-selection signal, seizes an outgoing international trunk line, establishes the connection to the distant network and triggers the answer-back of the called station, where it is required. The answer-back text received on the teleprinter of the calling U S. subscriber indicates a successful connection. If the called subscriber is busy, a printed service signal OCC (Occupied) is received instead

Disconnecting a Call

The calling subscriber may terminate the Telex connection in one of several ways. (1) activate the STOP button on the teleprinter's dial control attachment, (2) transmit from the keyboard the EOT (end-of-transmission) character in the case of four-row TWX station and (3) request "chargeable international time" from the computer by sending five characters M or five periods . . .

With routines (1) and (2), the disconnect signal releases the call sequentially beginning at the calling subscriber end. When the subscriber asks for "chargeable international time" (3) the computer releases the international connection and transmits to the requesting station a service text which e.g. would be received as 005 min. The domestic connection is then automatically released by the computer.

In general, Telex connections are terminated by the calling subscriber. However, if the called station does terminate the call, the computer is programmed to return "chargeable international time" to the calling (U S.) subscriber.

Conclusion

Computerized Telex switching represents a significant advance in the application of data processing equipment to the field of communications. It combines the elementary features of conventional line switching systems with enhanced operating capabilities, such as code/speed conversion, data signal regeneration, automated billing and provides many novel peripheral services to the Telex subscribers. Additionally, corrective maintenance routines become greatly simplified due to diagnostic print-out data

* * * *

i. s. & s. department relocates in mahwah, n. j.

The Mahwah Information Systems and Services Computer Center was opened on February 20, 1967, in Mahwah, New Jersey.

This building will house those I S &S Department operations such as:

Business Expansion

Western Union Systems Projects

Marketing

Equipment Planning and Engineering

Management and Resources Planning

Finance and Contract Administration

Administration

The Mahwah building will have a large development computer laboratory plus an operating center for the Security Industry and Information Services computers.

cable extension systems for carrier multiplex basebands

T. Thomas Maekask

The Western Union Transcontinental Microwave System basically consists of two sets of equipment, radio and carrier multiplex. The carrier multiplex equipment is of the frequency division, single sideband type, which translates the various audio and data channel input frequencies up to one broad frequency spectrum called a baseband. This baseband is then connected to the radio equipment where it is modulated to microwave frequencies.

At most stations, the two sets of equipment are located in the same room and their basebands are connected by a short length of coaxial cable such as RG-11/u. However, at many of the terminal stations, it was found necessary to locate the radio equipment in a different building from its associated carrier multiplex equipment. This separation of the two sets of equipment was made necessary because of the operating conditions imposed at these stations.

The location of the radio equipment was predetermined by such factors as line-of-sight path clearance to the next radio station. Consequently, many existing Western Union buildings could not be used. Normally, space for the radio equipment was leased in a relatively tall building near the vicinity of the Western Union building.

For the most economical and most efficient transmission, the carrier multiplex equipment should be located near its voice frequency (or higher frequency) input and output facilities. This eliminates numerous and lengthy audio-pair cable runs which tend to pick up low frequency noise and require individual amplification and equalization.

To connect the radio equipment and carrier multiplex equipment at such terminal stations, Western Union specified an economical cable extension system capable of transmitting the entire send and receive basebands of the radio/carrier multiplex equipment without degrading the quality of the overall microwave system transmission. These systems contained only amplifiers, amplitude equalizers, and impedance matching networks to compensate for the effects of either a coaxial or video pair cable connecting the two sets of equipment. Previously, cable extension systems used by Western Union had contained only a small number of voice channels, such as twelve channel basegroups or even individual voice channels.

240 Voice Channel Cable System

The first cable extension system was specified for terminals where the radio equipment capacity was 240 voice channels, with a baseband frequency spectrum from 60 KHz to 1052 KHz. Performance specifications were developed for a cable extension system, capable of handling this traffic load without significant degradation in quality of voice channels. General Electric Co. was contracted to design and manufacture the first 240 voice channel Coaxial Cable Extension System which was installed and tested during the latter part of 1962. Because of the urgent traffic needs, the finalized 240 voice channel Cable System was installed in practically all of the Radio Beam terminal stations as an interim measure, before installing the higher capacity systems.

960 Voice Channel Cable System

The next logical step in the expansion was a 600 (60 KHz—2540KHz) voice channel capacity system to match the existing maximum radio equipment load capacity. However, it appeared more advantageous to develop a 960 (60 KHz — 4028 KHz) voice channel system since there appeared to be no design problem with the equipment. Therefore, it was decided to forego the 600 voice channel capacity system and proceed with the 960 voice channel. The performance specification for 960 voice channel coaxial cable and video pair extension equipment used the experience gained during the installation and testing of the 240 voice channel system. The 960 voice channel equipment permits the transmission of basebands containing up to 960 voice channels over coaxial cables with lengths up to 2½ miles or over 16 gauge video pairs with lengths up to one mile. Each voice channel can be loaded with telegraph channels whose aggregate level is 15 db below the voice channel test tone level. Amplitude equalizing networks, for equalizing any length coaxial cable up to 2½ miles in ⅛th mile increments, and for equalizing any length video pair cable up to 1 mile, in 1/16th mile increments, were provided. Although all new terminal stations of the Microwave System have installed coaxial cable, several existing sites (such as Chicago and Cincinnati) already had video pair cable installed between the radio and multiplex locations.

Cables

At each of the microwave terminal stations, 2 composite cables consisting of four coaxial tubes and 26 #19AWG quads, were usually installed. These cables used different routes whenever possible for maximum protection from accidental damage from either natural or man-made hazards.

The cable construction consisted of four 2.6/9.5 mm. or 0.104/0.375 in. (diam. of center conductor/interior diam. of outer conductor) air dielectric coaxial tubes with polystyrene discs (spacers) and paper insulation. The insulation of the 26 #19AWG quads consisted of paper string and paper tape. The sheath of the overall cable was 0.016 inch Weilenmentel steel with a 0.060 inch minimum polyvinylchloride compound jacket.

It was later found that composite cables, with the above construction, required the use of teflon discs, rather than polystyrene, when located in the vicinity of high temperature, such as next to steamlines. They also required a lead sheath with a neoprene jacket.

The attenuation of a coaxial tube may be computed from the following formula:

$$\text{attenuation} = 3.8\sqrt{f}\ \text{db/mile at } 25^\circ\text{C}$$
(where f is in megacycles/second)

The impedance of every coaxial tube in a cable is 75 ± 1.5 ohms, unbalanced, at 2.5 MHz. The impedance at any other frequency between 60 KHz and 6.0 MHz is uniform along the length of the cable.

The video pair cable construction consists of eight shielded #16 AWG copper, twisted video pairs each insulated with foam polyethylene. Each pair is shielded with a longitudinal copper tape and a helically applied copper tape. Paper insulation covers each pair. Also included in the cable are 24 #19AWG, paper insulated pairs. The overall sheath is lead.

The attenuation of a video pair may be computed from the following formula:

$$\text{attenuation} = 8.3\sqrt{f}\ \text{db/mile at } 20^\circ\text{C}$$
(where f is in megacycles/second)

The characteristic impedance is 125.5 ± 3.5 ohms, balanced.

Equipment Performance

A simplified block and level theory diagram of a typical 960 voice channel Cable Extension System is shown in Fig. 1.

As can be seen from Figure 1, two identical sets of equipment (normal and standby) are installed for both the send and receive transmission paths for maximum protection to traffic. All the equipment required for the cable system is mounted on two standard 8 foot multiplex racks, one located at the multiplex terminal, the other at the radio terminal.

Manual switches are provided at the multiplex terminal to individually switch either the normal send or receive trans-

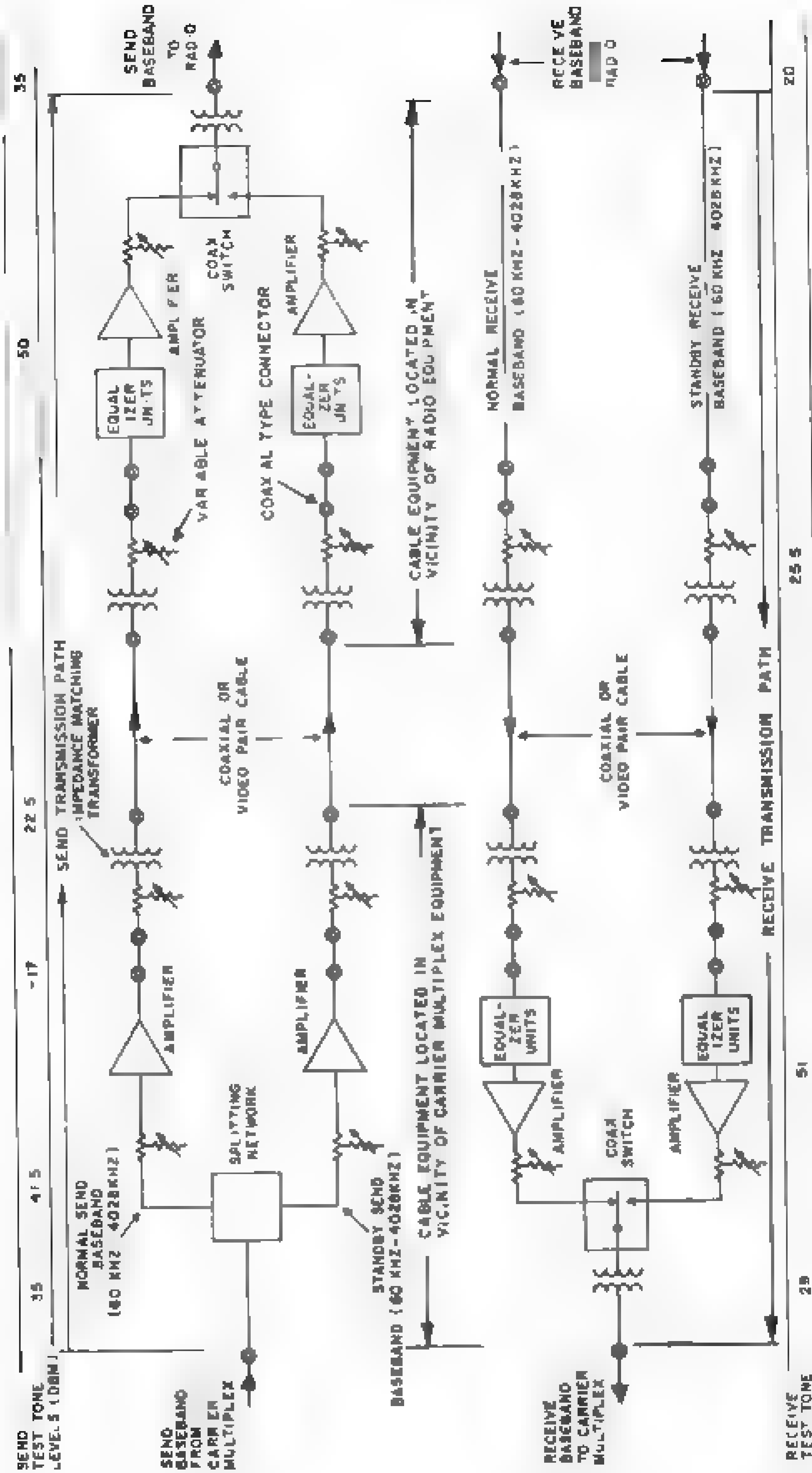

Figure 1.—Simplified Block Diagram of 960 Voice Channel Cable Extension System

mission path to standby. The coaxial relay for switching the send transmission path to standby is located on the cable rack at the radio terminal. The current required to operate this relay is supplied from a power supply on the cable rack located at the multiplex terminal. An indicator light is equipped at the multiplex end to show if the send transmission path is on normal or standby

The receive transmission path coaxial relay is mounted on the cable rack at the multiplex terminal. No indicator light was provided for this relay

Two rack alarms are supplied on the cable rack at the multiplex terminal. One alarm indicates the failure of either the normal or standby power supply or a fuse failure in any of the amplifiers on that rack. The other alarm indicates a fuse failure in any amplifier equipped on the cable rack at the radio end

Unless otherwise stated, all performance figures given below are valid with up to 2½ miles of coaxial cable or 1 0 miles of video cable between the radio and carrier multiplex equipment locations

a. *Idle Noise*

When the Send Transmission Path is disconnected from the carrier multiplex equipment, the idle noise level, measured at the —35 dbm send test tone point at the radio end, does not exceed a maximum aggregate level of —71 dbm between 60 KHz and 4028 KHz or a maximum of —101 dbm in any 4 KHz slot within this bandwidth

When the Receive Transmission Path is disconnected from the radio equipment, the idle noise level measured at the —29 dbm receive test tone point at the carrier multiplex end does not exceed a maximum aggregate level of —68 dbm between 60 KHz and 4028 KHz or a maximum of —98 dbm in any 4 KHz slot within this bandwidth.

b *Loaded Noise*

When the Send Transmission Path is loaded with white-noise at an aggregate RMS level of —20 dbm across the spectrum 60 KHz to 4028 KHz (—15 dbm0 loading per 4 KHz band), the signal to noise ratio with test tone as reference is 66 db or better in any derived voice channel

When the Receive Transmission Path is loaded with white-noise at an aggregate RMS level of —5 dbm across the spectrum 60 KHz to 4028 KHz (—15 dbm0 loading per 4 KHz band), the signal to noise ratio with test tone as reference is 69 db or better in any derived voice channel

c. *Amplitude vs. Frequency Response*

In a single direction and including a 2½ mile coaxial cable or 1 mile video cable, the amplitude vs. frequency characteristics of the system does not vary more than ± 1 1 db throughout the range 60 KHz to 4028 KHz. Furthermore, within any supergroup (240 KHz bandwidth), the response does not vary more than ± 0.4 db, and in any 4 KHz slot the response does not vary more than ± 0.05 db. At increments of cable lengths less than the above, the frequency response characteristics are the same or better than that specified for 2½ miles.

Special Systems

Connecting the Washington, D.C. terminal multiplex equipment to the radio system posed a special problem. The radio equipment could only be located at the Tenley Tower site, a distance of approximately six miles from the Washington terminal. To connect the send and receive basebands between the two sites, a 6 2 mile composite coaxial cable was installed. In order to avoid expensive cable repeater systems, two 240 voice channel Cable Systems were installed on a back-to-back basis. Since two 240 voice channel systems could only equalize a maximum of five miles of coaxial cable, additional equalization and amplification was required to equalize the entire 6 2 miles of cable

The equipment required to obtain this equalization was installed during the early part of 1964 and engineering tests were made to measure the performance of such a system. Although the results were not as good as those obtained on a standard 240

voice channel Cable System, they were still very acceptable for transmission of traffic. A brief summary of the more significant test results obtained is given below:

Attenuation vs. Frequency Response (any direction)
: +0 3 db to −1 1 db between 60 KHz and 1052 KHz relative to a 500 KHz reference test tone

Loaded Noise
: With either the send or receive transmission path loaded with white-noise at a level of −15 dbm0 per 4 KHz band, the signal to noise ratio with test tone as reference was better than 70 db in every derived voice channel.

Near End Crosstalk
: Better than −65 dbm0 between 60 KHz and 1052 KHz with a test tone at 0 dbm0 inserted at the sending baseband input and measured at the receive baseband output at the same terminal

This system is presently being engineered to handle at least 600 voice channels without repeaters

Other special cable extension systems have also been installed such as at the Jet Propulsion Laboratories, Pasadena terminal, however, these did not introduce any serious technical problems since the distances covered were normally much less than 2½ miles.

Radio Beam Expansion

At the present time, Western Union is in a process of expanding its existing 600 voice channel multiplex and radio equipment to at least 1200 Voice Channels. This expansion means that even larger capacity Cable Extension Systems will be required Therefore, engineering evaluations are being made of Cable Extension Systems capable of handling at least 1200 voice channels

T Thomas Maekask is Supervisor of the Carrier Multiplex Equipment in the Transmission Systems Section of the Information Systems and Services Department He joined Western Union in June 1960, at which time he was assigned to the engineering of the 600 voice channel carrier multiplex equipment used in the Radio Beam Expansion Project. He is presently concerned with improving the performance of this equipment. Also he is participating in the engineering evaluation of future multiplex expansion to 1200 voice channels.

Mr. Maekask received his B.E.E. degree from Union College in 1960. He is currently studying for a M E E. degree at New York University

AUTODIN expansion

A new computer operated communication center was opened at the Marine Corps Supply Center, Albany, Georgia to meet the growing communication needs of the Defense Department. This is the eighth center in the United States to be brought into operation.

The original five-center, AUTODIN system, completed by Western Union early in 1963, now serves more than 700 tributaries.

Under the expansion program, capacity of the first five centers is being greatly expanded. Four new centers are being added and the number of tributaries increased to approximately 2,400.

The number of computers will increase from 10 to 18, and the system's capacity will more than double, permitting a daily transmission of 24 million punched cards — the equivalent of 320 million words.

The Department of Defense has designated the DCS AUTODIN as its primary communications system for data and other record traffic.

AUTODIN, as it is designed to function, is an integral part of the Defense Communication Agency's world-wide communication complex. It will provide high-speed interchange of vital telecommunications for the Department of Defense, not only between Air Force, Army, and Navy installations, but also with other DOD subscribers including industrial plants which provide direct support for weapons systems.

With the completion of the system all military departments of the Department of Defense and some other government agencies will be users of the AUTODIN.

pilot alarm system for carrier multiplex

James L. Anderson

The TCS 600 carrier multiplex equipment associated with the Western Union Transcontinental Microwave Network has a unique Pilot Alarm System, which monitors the transmission path continuity of all group (48KHz) and pregroup (16 KHz) frequency blocks at all terminal stations and manned junction stations in the microwave network. The Pilot Alarm System was designed by General Electric to meet unique performance requirements specified by Western Union

In a large and extensive carrier multiplex microwave system with grid network avoidance routing of the main radio beam trunks through junction stations and a large number of spurs off the main trunk routes, there are many insertion, termination, and junction points for the individual transmission paths. It is desirable to monitor these points throughout the system so that failures can be quickly localized without extensive trouble-shooting of the entire transmission path.

The Western Union standards for a 600 voice-channel (4KHz) frequency division carrier multiplex system follow CCITT allocation of the baseband frequency spectrum between 60 and 2540 KHz. The primary subdivision of the baseband spectrum is ten 60 voice-channel supergroups (312 552 KHz). The basic supergroups are further divided into five 12-channel basegroups (60-108 KHz). Under some circumstances, for maximum utilization of the group spectrum, basegroups are further divided into three 4-channel pregroups (8 24 KHz) with the following frequency allocations in the basegroup spectrum: 92-108KHz (Pregroup 1), 76 92KHz (Pregroup 2), and 60 76KHz (Pregroup 3).

Pilot Alarm System

The Pilot Alarm System is basically a system for inserting frequencies of 72-, 88-, and 104 (or 104 08) KHz as pilot tones into the send groups of the multiplex at the originating terminal and monitoring these tones as they appear in the transmission path. When the tone level of any given transmission path drops a predetermined amount, visual and audible alarms are activated at all monitoring stations between the point of failure and the receiving terminal to alert operating personnel The 104 (or 104 08) KHz tone is associated with Pregroup 1, the 88 KHz tone is associated with Pregroup 2, and the 72 KHz tone is associated with Pregroup 3. In groups which are not divided into pregroups, only the 104 (or 104 08) KHz tone is inserted

The pilot tones are inserted at a nominal level of 20 db (—20 dbm0) below voice-channel test tone level An alarm is indicated when the pilot tone level at a detection point drops at least 10 db below the nominal tone level. Design criteria specified that the equipment be capable of monitoring the tones as they appear in the baseband, translated to frequencies up to 2540 KHz, and intermingled with telegraph traffic less than 400 Hz away at these frequencies

Once the pilot tones are inserted, they are continuously present at all monitoring points in the transmission path However

because of the large number of transmission paths that must be monitored, the tones are monitored repetitively rather than continuously. The sampling rate is adjustable and is nominally set at ten tones per second; thus it requires approximately 15 seconds to monitor an entire baseband containing 150 tones.

Components of System

Two types of racks are used in the Pilot Alarm System: the Pilot Alarm Rack, and the Group Crystal Amplifier Rack. The Pilot Alarm Rack contains all equipment necessary for inserting and monitoring the pilot tones, except the Group Crystal Amplifiers. The display portion of this rack consists of an indicator lamp for each monitored tone. Each indicator lamp is numbered with the carrier system number of the group or pregroup transmission path, so that the failed tone can be readily identified.

Figure 1 shows a typical Pilot Alarm Rack used at a Western Union terminal station. Three basic variations of this rack

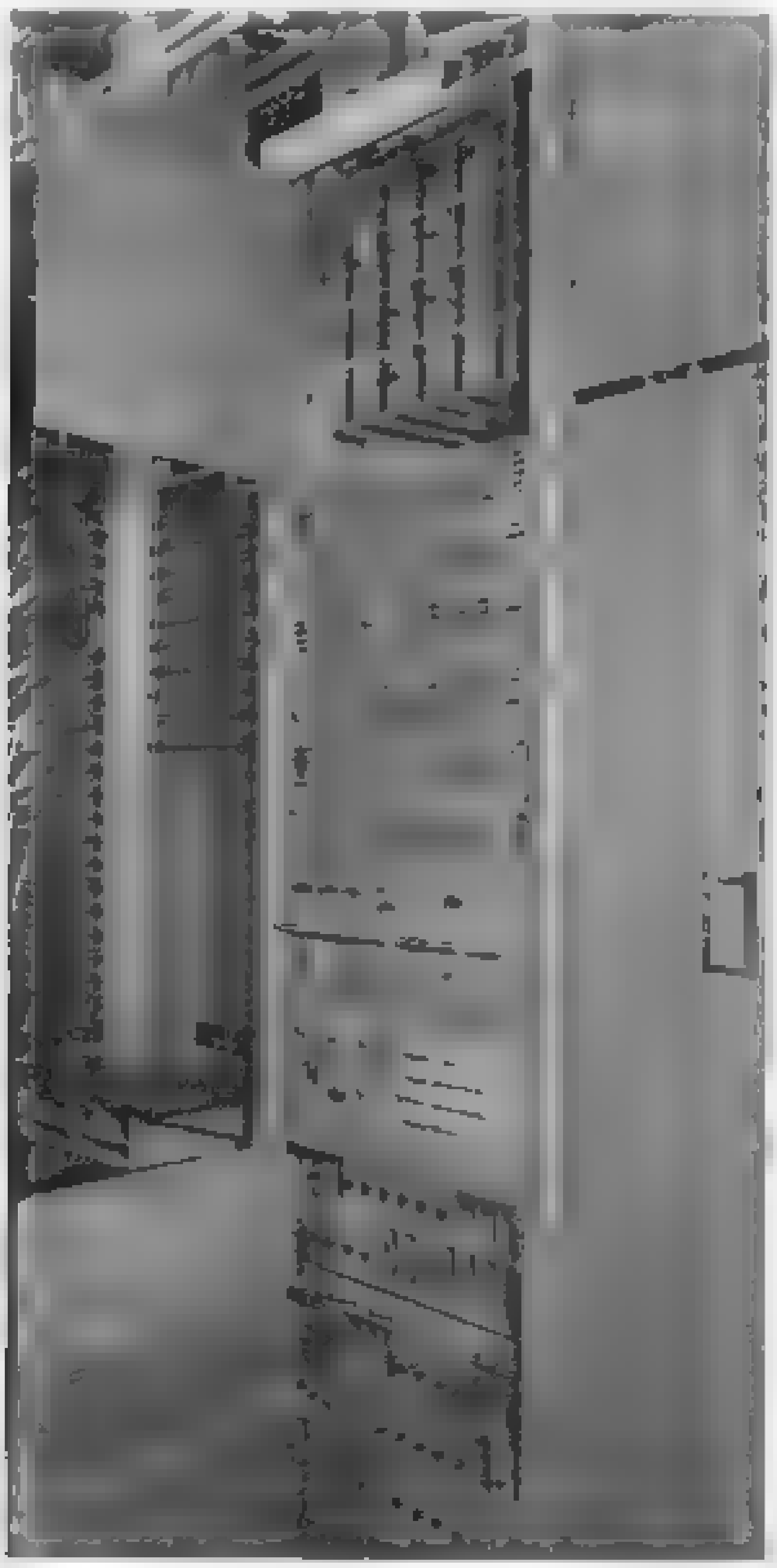

Figure 1. Pilot Alarm Rack

are used to accommodate the basic differences between Western Union terminals, USAF terminals, and Western Union manned junctions.

The Group Crystal Amplifier Rack, shown in Figure 2, is very similar in size and appearance to a standard eight-foot multiplex channel rack. It contains a standard power supply and can accommodate up to one hundred Group Crystal Amplifiers. One amplifier unit is required for each receive group at a terminal station Thus, the rack has the capacity to accommodate up to one hundred receive basegroups, or all the receive basegroups in two complete 600 voice-channel basebands.

The pilot alarm equipment, like the multiplex system, has been designed for maximum flexibility, utilizing a building block principle, so that only the shelves and units necessary to insert tones and monitor the given transmission path configuration at a particular station need be installed in the racks. Additional shelves and units may be added to meet increased requirements. Like the carrier multiplex equipment, all units in the Pilot Alarm System utilize solid state circuitry to reduce space, power, and maintenance requirements.

The electronic circuits for each module are packaged as plug-in units, mounted on printed circuit boards. Module packaging follows the segregation of functions into logical and easily-isolated units. To facilitate maintenance and testing, extender boards are provided which permit trouble shooting and circuit analysis of individual modules during actual operation

The Pilot Alarm System operates independently of the carrier multiplex equipment, except for the generation of 72 , 88 and 104-KHz pilot frequencies, which are obtained from the Channel Carrier Selectors in the multiplex. In designing the alarm equipment, it was found unnecessary to provide independent generation for these frequencies, since they can be obtained from the Channel Carrier Selectors without overloading them. However, when the 104.08 KHz frequency is inserted, it is derived from an independent oscillator supplied at the station.

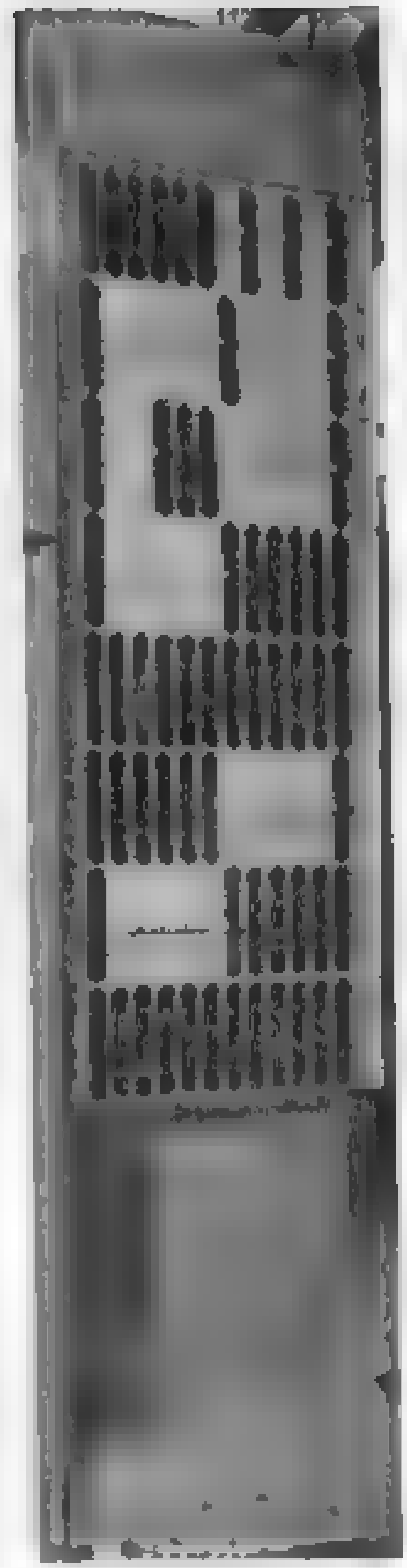

Figure 2. Group Crystal Amplifier Rack

System Requirements

Figure 3 is a simplified layout of the microwave network, showing the locations of those stations where Carrier Multiplex and Pilot Alarm equipments are installed.

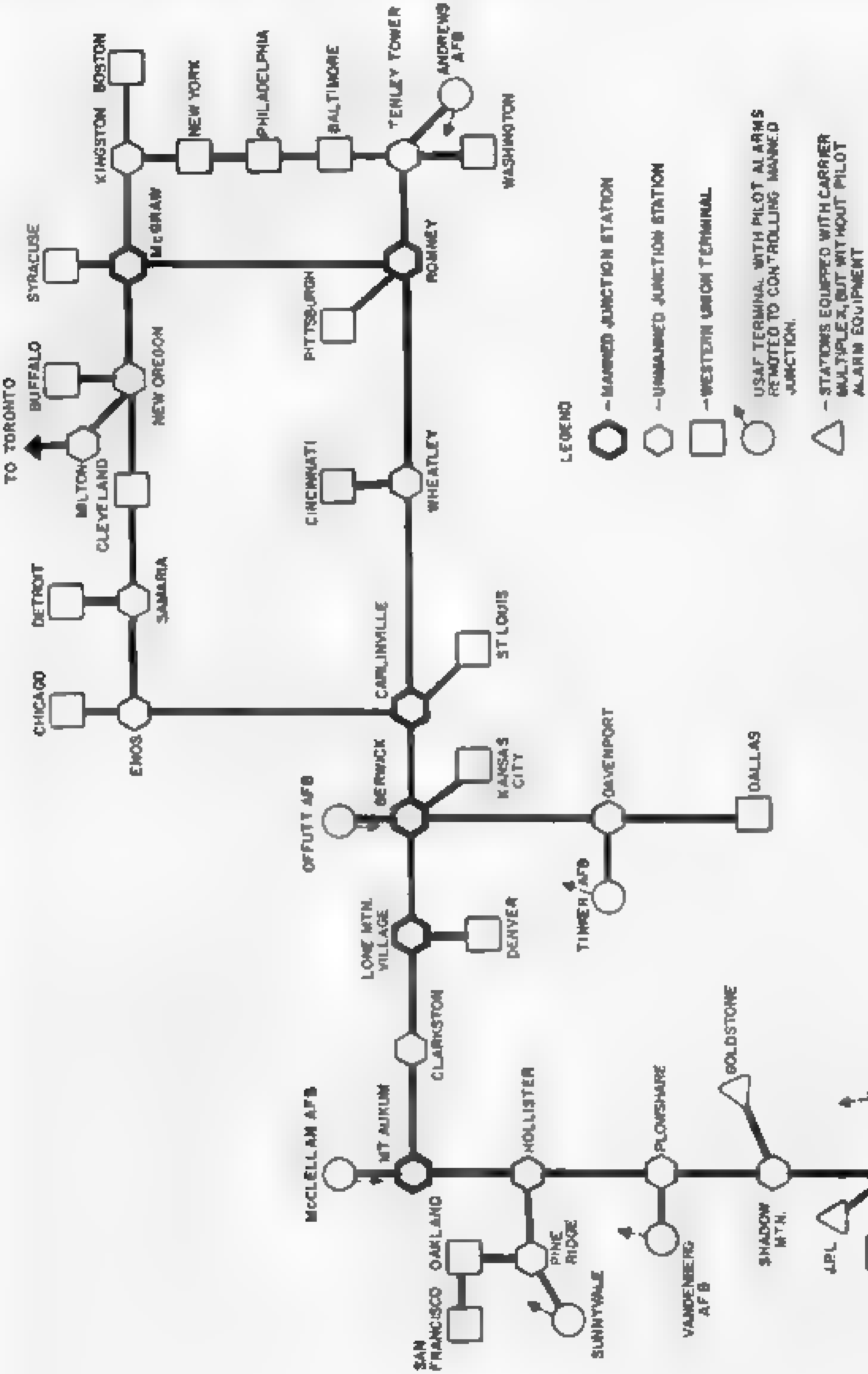

Figure 3. Western Union Microwave System

These stations are of two basic types: (1) terminal stations where microwave beams originate and terminate, and (2) junction stations where the beams are broken down into frequency blocks and rerouted

At terminal stations, the individual 4 KHz voice channels are combined into pregroup, group, and supergroup blocks, which are modulated to baseband frequency (60-2540 KHz) and transmitted on the radio beam. The terminals consist of both Western Union terminal stations and terminals at U.S. Air Force bases which are maintained and operated by Western Union, but are not continuously manned by Western Union personnel. At junction stations, the received radio beams are demodulated to frequency blocks which are interconnected into the other send beams for transmission. The junction stations may be manned or unmanned junction stations. The manned stations are primarily major junctions where three or more trunk routes intersect; the unmanned stations are minor junctions where a trunk route is intersected by a terminal spur system which serves either a city or a customer location. The manned junction stations, in addition to monitoring the pilot tones in all send and receive basebands, also serve as remote fault reporting and control points for the unmanned junctions, repeater stations, and USAF terminals within assigned control areas. Some terminals, such as New York, are defined as terminal junction stations where both terminated traffic and interconnected traffic are in the same baseband

A terminal-type Pilot Alarm Rack and a Group Crystal Amplifier Rack are installed at each Western Union and USAF terminal station. A junction-type Pilot Alarm Rack is installed at each manned junction station The Pilot Alarm Rack at Western Union terminal stations has the capability to monitor and display alarms for all of the pilot tones in two send and two receive basebands, and all of the basegroups in two receive basebands. The Pilot Alarm Racks at the USAF terminals are slightly different since these terminals are not continuously manned by Western Union personnel. Therefore, their alarms must be remoted to the controlling manned junction station. To simplify remoting, only one tone per basegroup is monitored at the USAF stations, regardless of whether the group is broken into pregroups or not; consequently, the alarm racks at these stations are capable of monitoring and displaying only one tone per group These alarm indications are transmitted through the radio fault reporting system to the controlling manned junction station

The Pilot Alarm Rack at a manned junction station can monitor ten 600 voice-channel basebands: five send and five receive. However, it is not equipped for monitoring at basegroup level. Since there is, theoretically, no terminating traffic at the manned junctions, the alarm rack is not equipped to monitor receive basegroups Normally, the only frequency blocks terminating at a junction station are spares which are monitored at baseband level However, the racks are equipped to insert pilot tones into spare groups which originate at the junction station. The GSA terminals associated with the manned junction stations at Romney, Berwick, and Mount Aukum are special cases requiring the installation of terminal type alarm racks.

Operation

Figure 4 illustrates a simplified modulation plan for inserting and monitoring pilot tones in one multiplex baseband at a terminal station. If pilot tones of 72 KHz, 88 KHz and 104 KHz are inserted at Point A into Group 1, Supergroup 1, they will appear in the baseband at the input of the radio transmission equipment, Point B, as three higher frequencies, namely, 264 KHz 280 KHz and 296 KHz. Similarly, pilot tones inserted into Group 2, Supergroup 1 will also appear in the baseband as three higher frequencies associated with Group 2, Supergroup 1. Further, insertion of 72 KHz, 88 KHz, and 104 KHz frequencies into all 50 groups composing a baseband will produce a spread of 150 tones over the baseband, with each set of three tones associated with the pregroup, group, and supergroup into which the tones were

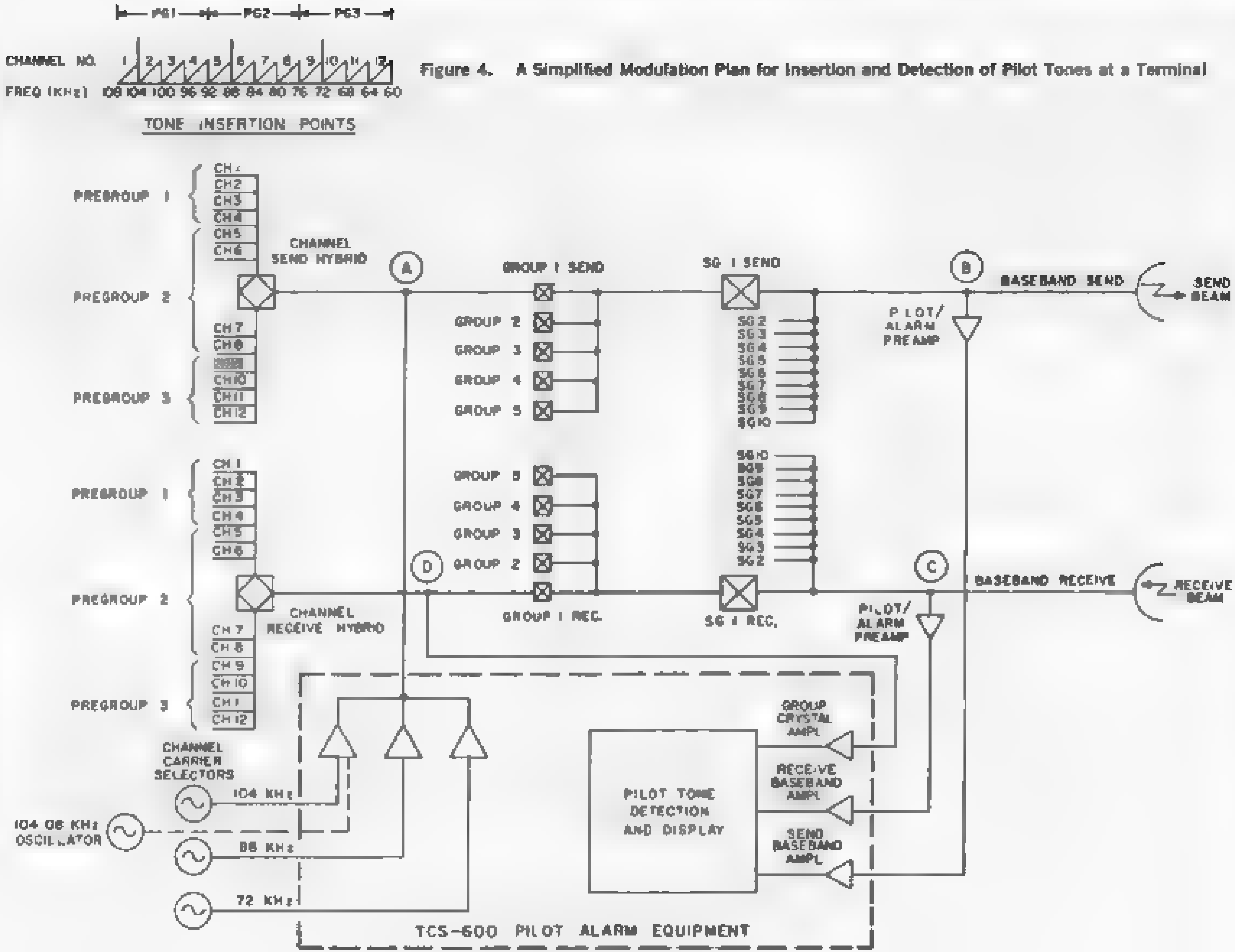

Figure 4. A Simplified Modulation Plan for Insertion and Detection of Pilot Tones at a Terminal

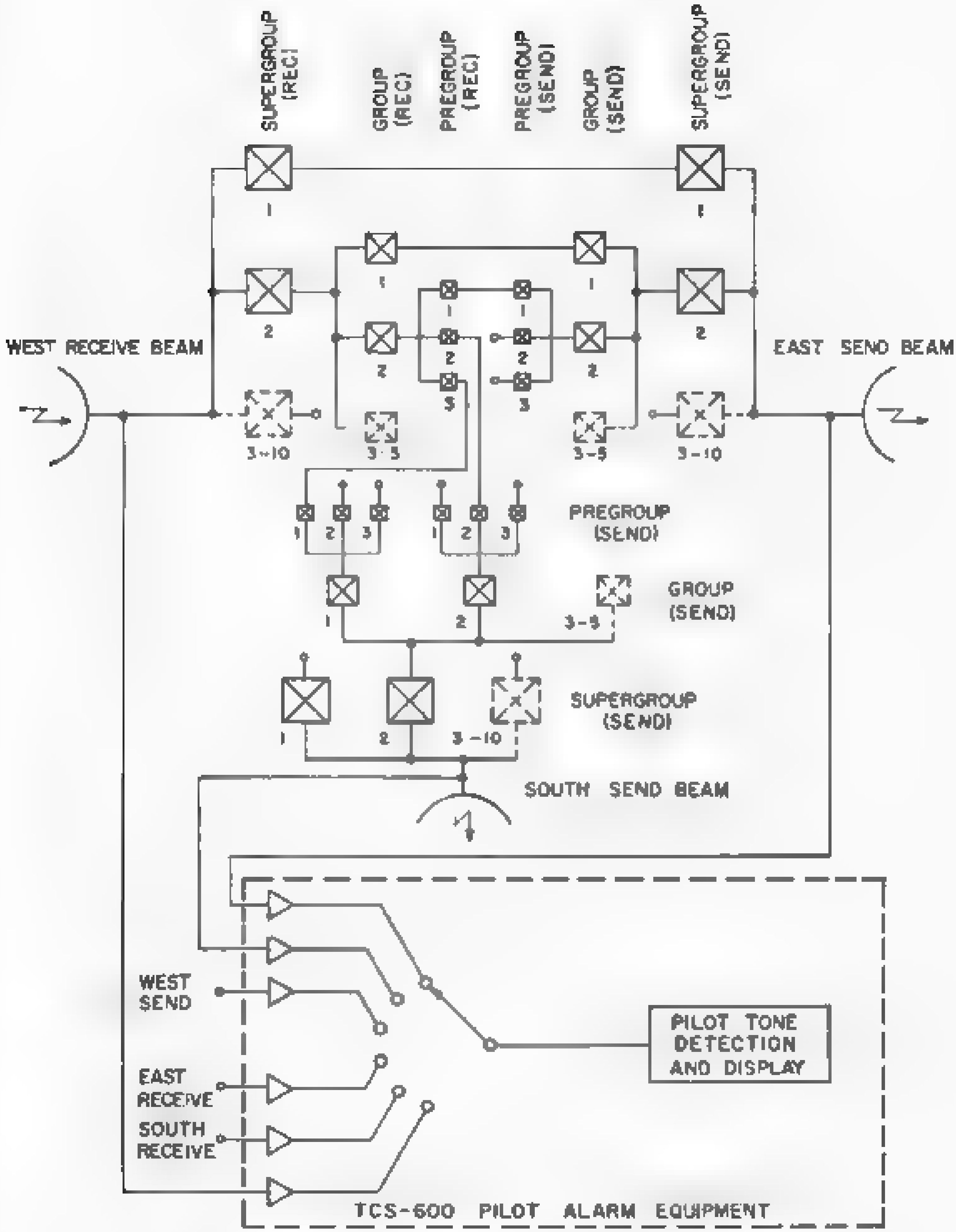

Figure 5. Demodulation and Interconnection of One Receive Baseband at a Manned Junction Station

TABLE I

PILOT TONE FREQUENCIES IN THE MULTIPLEX BASEBAND (KHz)

Group	Pre-Group	Pilot Tone (KHz)	SG1	SG2	SG3	SG4	SG5	SG6	SG7	SG8	SG9	SG10
1	1	104	296	316	800	1048	1296	1544	1792	2040	2288	2536
	2	88	280	332	784	1032	1280	1528	1776	2024	2272	2520
	3	72	264	348	768	1016	1264	1512	1760	2008	2256	2504
2	1	104	248	364	752	1000	1248	1496	1744	1992	2240	2488
	2	88	232	380	736	984	1232	1480	1728	1976	2224	2472
	3	72	216	396	720	968	1216	1464	1712	1960	2208	2456
3	1	104	200	412	704	952	1200	1448	1696	1944	2192	2440
	2	88	184	428	688	936	1184	1432	1680	1928	2176	2424
	3	72	168	444	672	920	1168	1416	1664	1912	2160	2408
4	1	104	152	460	656	904	1152	1400	1648	1896	2144	2392
	2	88	136	476	640	888	1136	1384	1632	1880	2128	2376
	3	72	120	492	624	872	1120	1368	1616	1864	2112	2360
5	1	104	104	508	608	856	1104	1352	1600	1848	2096	2344
	2	88	88	524	592	840	1088	1336	1584	1832	2080	2328
	3	72	72	540	576	824	1072	1320	1568	1816	2064	2312

originally inserted. Table I lists all 150 tone frequencies as they would appear in a typical baseband if pilot tones are inserted into all groups.

Figure 5 illustrates a typical demodulation and interconnection of one receive baseband at a manned junction station. Assuming that the entire baseband of the West beam is composed of 16 KHz pregroup frequency blocks, then the pilot tones inserted at the originating terminals working into the West beam will appear in the baseband spectrum at those frequencies given in Table I. Thus, after the West beam is demodulated, Supergroup 1 receive is interconnected to Supergroup 1 send of the East beam, and the 15 tones associated with Supergroup 1 will appear in the East beam for transmission to the next station

At the same time, Supergroup 2 of the West beam is demodulated to basegroup frequencies. Group 1, Supergroup 2, with its three associated tones, is then connected to Group 1, Supergroup 2 send of the East beam, for transmission to the next station. Group 2, Supergroup 2 is demodulated to pregroup frequencies, and the three pregroups, each with its pilot tone, appear at the three pregroup receive units. The Pregroup 1 tone follows the path to Pregroup 1, Group 2, Supergroup 2 in the East send beam; the Pregroup 2 tone follows the path to Pregroup 2, Group 2, Supergroup 2 in the South send beam; and the Pregroup 3 tone follows the path to Pregroup 1, Group 1, Supergroup 2 in the South send beam.

Referring again to Figure 4, it can be readily seen that the pilot frequencies inserted at the originating terminals will appear in the receive baseband at the receiving terminal, point C. The 72 KHz, 88 KHz, and 104 KHz tones will appear in the demodulated basegroups, point D

The foregoing description assumes that three tones are inserted into each group at the originating terminal. However, for minimum loading of the microwave system, only those tones necessary to monitor the operating paths are actually inserted. For example, for a group going from the originating terminal to its destination without demodulation to pregroup level en route, only one tone is inserted, namely, the 104 KHz tone.

Summary

To summarize the monitoring process performed by the Carrier Multiplex Pilot Alarm System, at each terminal station, pilot frequencies of 72-, 88-, and 104 (or 104.08) KHz are inserted into each send group. If the group is divided into pregroup frequency blocks, a tone is inserted for each pregroup; the 104 KHz tone is associated with Pregroup 1, the 88 KHz tone is associated with Pregroup 2, and the 72 KHz tone is associated with Pregroup 3 If the group is not divided into pregroups, only the 104 (or 104 08 KHz) KHz tone is inserted. The inserted tones appear in the baseband, after the modulation process, at frequencies given in Table I

In terminals which are spurs of manned junction stations, the send baseband is not monitored since the tones will appear in the receive baseband at the manned junction station. When alarms occur they are reported back to the terminal by the operator at the manned junction. In a terminal which is a spur of an unmanned junction station, it is necessary to monitor the send baseband, since the tones will not be detected again until they are received by the next manned junction.

In the manned junction station, the pilot tones in all send and receive basebands are monitored so that both incoming and outgoing faults will be detected. A fault indication on an incoming baseband indicates that a failure exists up the line, and enables coordination of troubleshooting between the sending terminal and other manned junctions in the transmission path. A fault indication on an outgoing baseband at a junction will naturally appear when the incoming circuit has failed; however, when outgoing faults are indicated and there is no fault on the incoming circuit, then a failure is indicated within the junction itself.

At the receiving terminals, the pilot tones in the receive basegroups are monitored after demodulation to basegroup frequency. At terminals which are spurs of manned junction stations, fault indications in the basegroups indicate failure in the station when no fault is reported by the sending terminal or the manned junctions in the transmission path. At terminals which are spurs of unmanned junctions, such fault indications indicate failure in the terminal or in the unmanned junction.

* * * *

References:

1. Engineering of Microwave Systems, W. H. French, Western Union TECHNICAL REVIEW, Vol. 14, No. 3, July 1960.
2. Engineering of Microwave Systems: Appendix, W. H. French, Western Union TECHNICAL REVIEW, Vol. 15, No. 1, January 1961.
3. Microwave Radio Beam System, J. M. Reardon, Western Union TECHNICAL REVIEW, Vol. [illegible], No. 4, October 19[illegible].
4. Basic Instruction Manual on Pilot Tone Alarm Equipment for [illegible] System [illegible] published by Communication Products Dept., General Electric Company, Lynchburg, Va.

James L. Anderson, applications engineer in the Informations Systems and Services Department, has been concerned with the application of the carrier multiplex pilot alarm systems to the development of system troubleshooting procedures for the TCS-600 carrier multiplex. He is presently employed on the microwave beam performance test project.

He joined Western Union in 1963. Prior to this, he was responsible for the documentation of the Pilot Alarm System at General Electric Co.

He received his B.S. degree from Xavier University, Cincinnati, Ohio in 1957 and attended several technical schools in the U.S. Marine Corps.

memo to our readers:

The publication of the 20 year Index to the Western Union TECHNICAL REVIEW has been postponed until April 1967

The Editor

duplex way systems

plan 117 and plan 137

by A. A. Ortiz

Among users of private wire communication systems, duplex way circuits have always been popular. However, new developments in the communications industry have made them more attractive. These developments include a reduction in the tariff rates for duplex way facilities and the application of computers to the control of duplex way circuits. Consequently, Western Union recognized a need for a new competitive and flexible selector which could be used to control input-output equipment at duplex way stations. The success of the Plan 115 system, used to control half duplex way circuits, had already established the reliability of new innovations such as, continuous polling, "V" answer backs, etc.

A new duplex Way Station Selector was designed which included all those features, proved successful in Plan 115 way stations. This selector was designed for use in a new system designated Plan 117.

In the early stages of its development, the Plan 117 system concept was adapted for a system using eight-level ASCII code terminal equipment and a computer to control the way station selectors. This new system was designated Plan 137, since the Plan 117 was limited to the control of way circuits which use five-level Baudot Code terminal equipment.

System Description

The following is a general description of Plans 117-B and 137-A using a Western Union Control Center 11709. If the way circuit is controlled by a computer, instead of the Center, the computer will provide the necessary functions normally assigned to the control center, referred to in this article as the processor.

The Plan 117-B and Plan 137 A systems are designed to control the sending and receiving equipment at the way stations of a full duplex way circuit. The system provides means for assuring that messages are not lost in transmission due to operator errors, or equipment and circuit malfunctions. A control panel at the processor provides a continuous display of the circuit status. The Plan 117-B may connect a maximum of 20 sending and receiving way stations to the processor, through a full-duplex class "C" facility operated at 60-, 75- or 100 WPM. The I/O equipment will use Baudot Code. The Plan 137-A may connect a maximum of 26 sending and receiving way stations to the processor through a full-duplex Class "D" facility operated at 100 wpm. The I/O equipment will use ASCII Code.

The processor may send to any one of the way stations while simultaneously receiving traffic from any one of the way stations. All messages originated at the way stations will be directed to the processor where, if necessary, they will be routed to other destinations. The transmitters at the way stations will be invited to send to the processor in a predetermined sequence, by means of control signals generated by the processor and de-

coded by the Way Station Selector. The transmitter at the processor will have continuous access to the circuit, and if sending, will be interrupted only to transmit the invitation signals or other control signals to the way stations.

The receiving equipment at the way stations will be conditioned to receive messages from the processor by means of the Way Station Selector at the way station, which is programmed to recognize selection control codes. Upon selection the way station will automatically generate an answer-back signal to the processor to indicate that it is ready to copy a message.

The receiving equipment at the processor is conditioned to receive and copy all messages from the way stations.

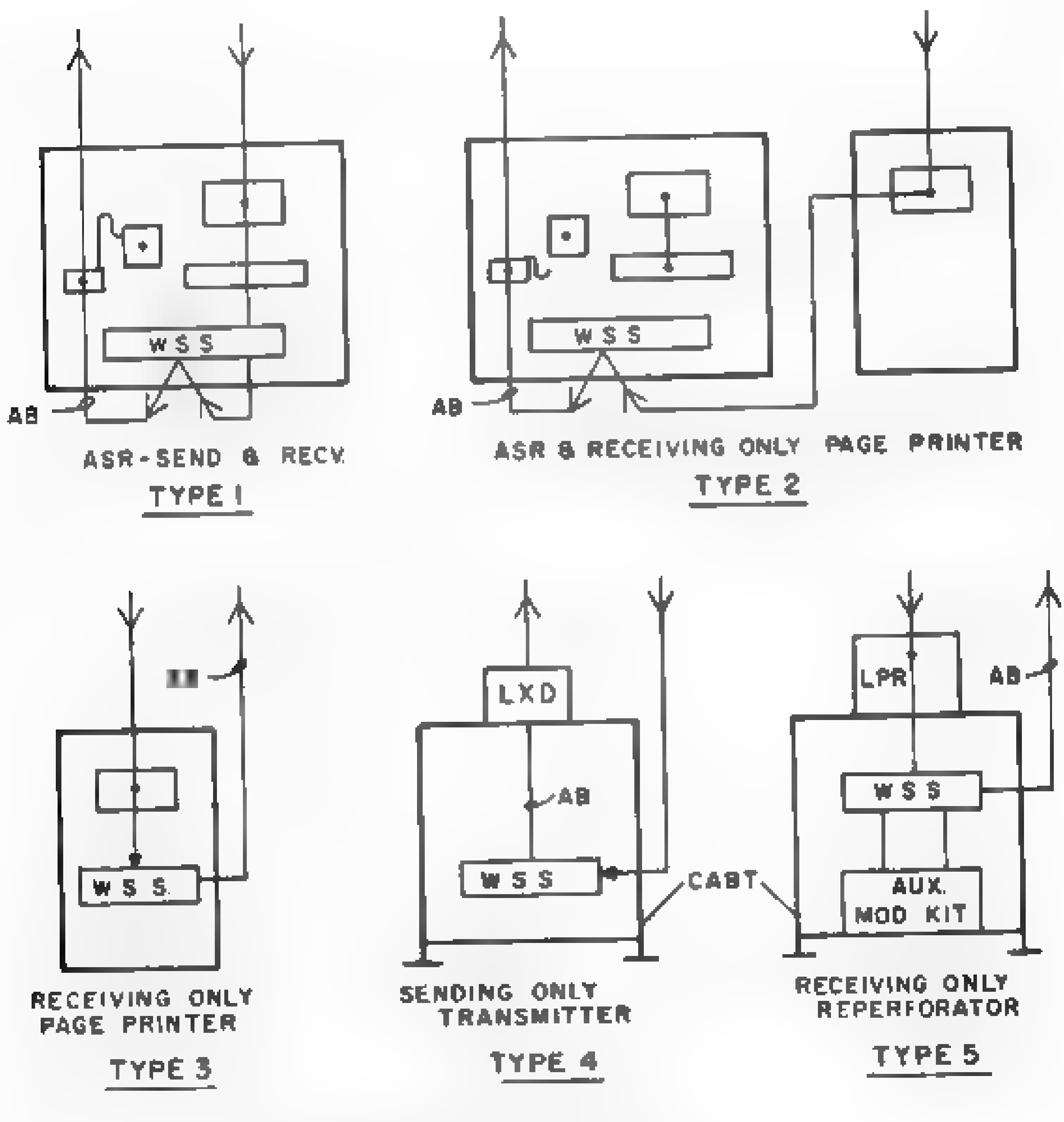

Figure 1. Five Types of Equipment Configurations for Way Stations

Terminal Equipment

Plan 117 B uses Teletype Model 28 equipment for sending and receiving messages. Plan 137 A uses Teletype Model 35 equipment for sending and receiving messages.

Five different equipment configurations or arrangements have been established to provide for special needs at the way stations. The five types shown in Figure 1 are:

Type I —Sending and Receiving—Type I uses a Teletype ASR Set. The Way Station Selector (WSS) is housed inside the ASR console. The typing unit copies traffic sent to the way station. The transmitter is used to send traffic from the way station. The keyboard and reperforator are used to prepare tapes to be transmitted. No page copy is made of messages transmitted.

Type II —Sending and Receiving—Type II uses a Teletype ASR Set and Receive Only Page Printer. The WSS equipment is housed in the ASR console. The RO page printer copies traffic sent to the way station. The ASR transmitter is used to send messages from the way station. The keyboard and reperforator are used to prepare tapes to be transmitted. The typing unit of the ASR is used to copy messages as they are prepared on the reperforator, or as they are being sent from the transmitter.

Type III—Receiving Only—Type III uses a Teletype Receive Only Page Printer equipped with a floor console. The WSS equipment is housed in the printer console. Messages from the processor are copied by the RO printer.

Type IV—Sending Only—Type IV is a Teletype Self Contained Transmitter. It is used to send messages to the processor. The Transmitter is mounted on Cabinet 11288.1 which also houses the WSS equipment.

Type V —Receiving Only—Type V is a Teletype Self-Contained Reperforator, as shown in Figure 2. It is used to receive messages from the processor in perforated tape. The reperforator is mounted on Cabinet 11288.1 which is also used to house the WSS equipment. Reperforator stations require special modification kits. These are described further under the section on OPTIONS.

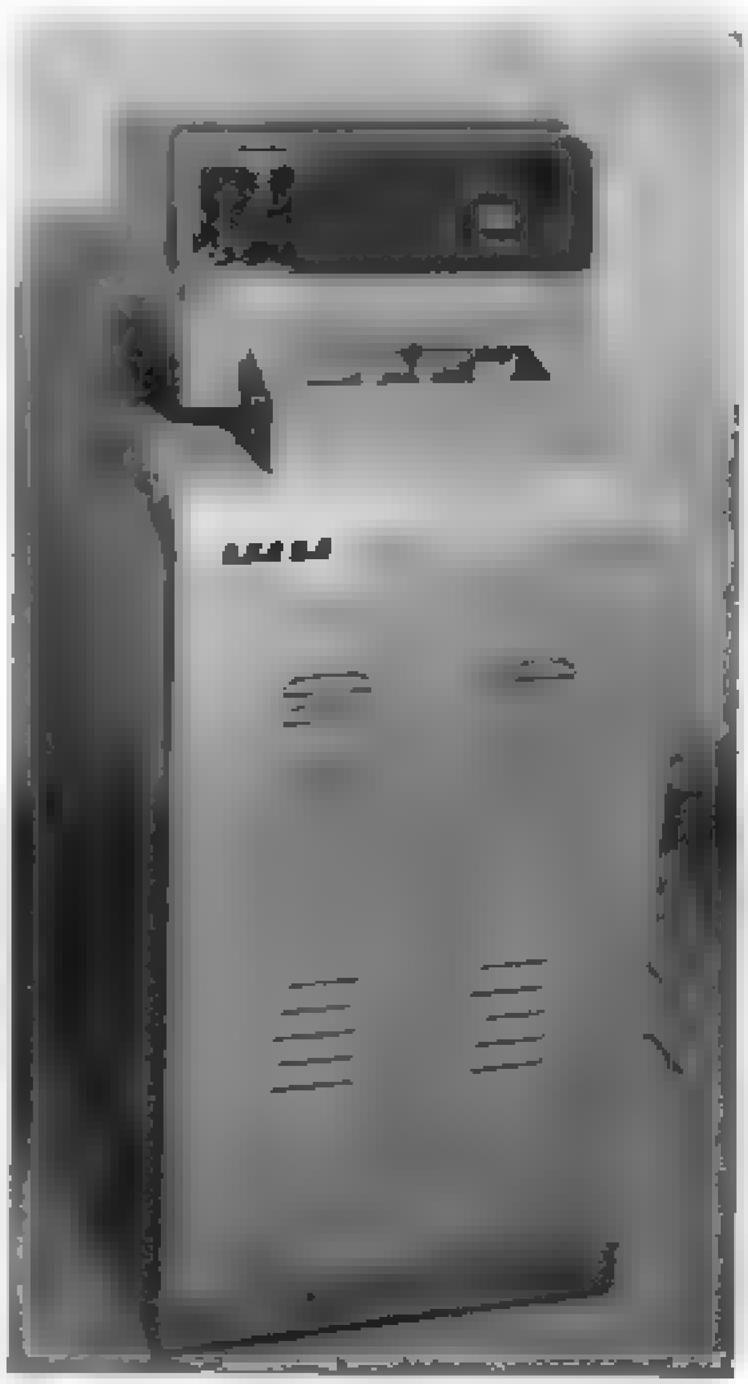

Figure 2. Type V Receiving Only Reperforator

Selector Components

The Way Station Selector consists of the following four basic components.

a. Control Panel, shown in Figure 3, "stores" a request to send a message; indicates normal and abnormal sending conditions, and disables the selector while replenishing paper or tape in the receiving unit

b. Electronic Card Chassis houses the program cards and Western Union logic circuit cards, which are used to decode and respond to control signals from the processor.

c. Wiring Cabinet or Equipment Shelf interconnects the outstation to the line and provides a 120 v dc supply to operate the Teletype I/O equipment.

d. Power Supply provides the regulated low voltage (±12 v dc) source required to operate the logic circuit cards.

The electronic card chassis, ECC 11704, used in the Plan 117 B and Plan 137-A is the heart of the Way Station Selector, W.S.S. It is a solid state device which uses Western Union standard logic cards and precludes the need for the Teletype "stunt box" to recognize system control signals. Its reliability and effectiveness have been repeatedly demonstrated, particularly when compared to electromechanical selectors operating at 100 wpm

It is a programmable unit which can be used to control equipment using five through eight level code and at speeds up to 1200 bauds. Its flexibility has made it possible to use it in the Plan 115 B, and Plan 135-A, both half-duplex systems, besides the Plan 117 B and Plan 137 A.

Processor Equipment

At the Control Center 11709, the Control Panel, the Equipment Shelf and the Power Supply will be used as in the way station. Another type electronic card chassis is required to house the Western Union logic cards needed to generate the control codes used to control the way stations. An additional control panel is provided to regulate the polling, identify the sending station, and indicate system abnormal conditions. The components required at the processor are housed in Cabinet 11288 1

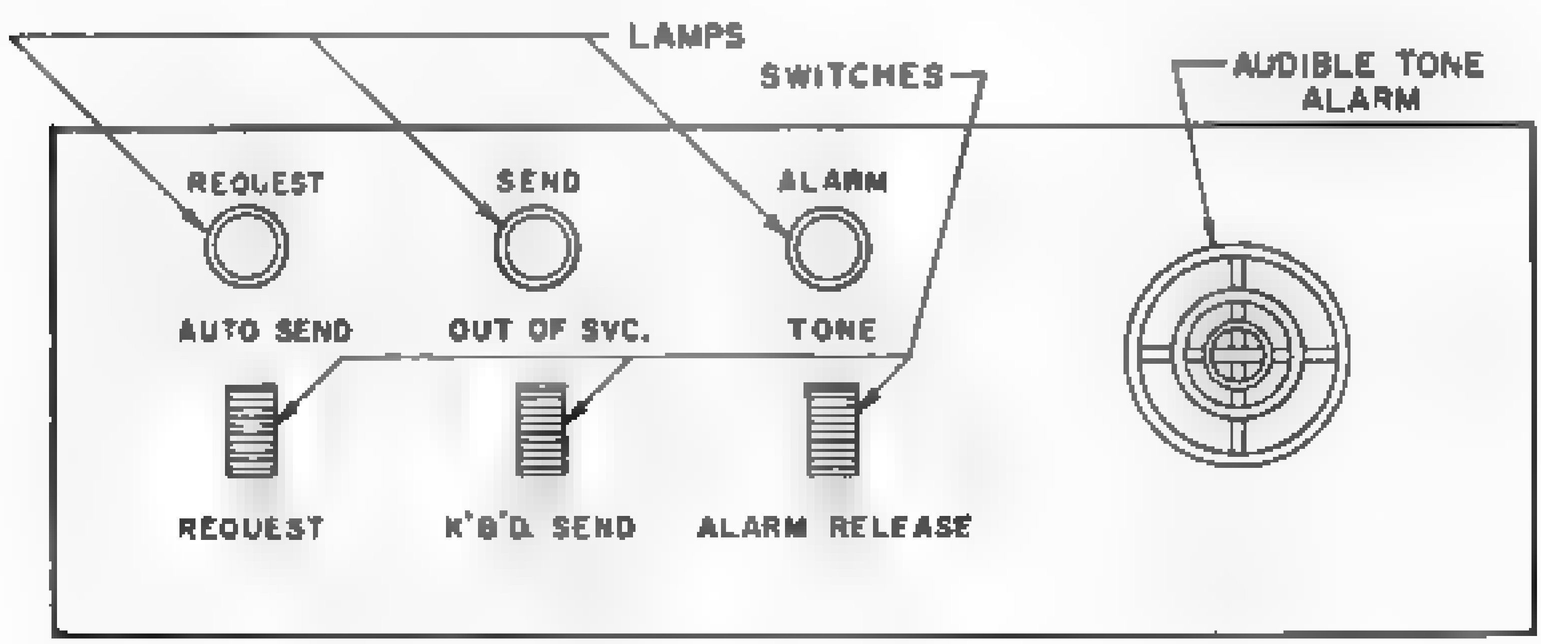

Figure 3. [redacted]

Operation — Modes and Codes

During the operation of the Way Station Selector, it is conditioned to respond to Control Codes which will

1. change the mode of the selector,
2. control the sending and receiving equipment at the way station,
3. generate a response signal upon receipt of certain control codes.

A brief explanation of the Selector Modes and the Control Codes follows.

Selector Modes

- **Select Mode (S)** — The selector must be in this mode in order to respond to the Start-Of-Message Code The selector is shifted to the Select Mode by the End-of-Message code and out of the Select Mode by the End-of-Address code.
- **Call Mode (C)** — The selector must be in this mode in order to respond to the station selector codes. The selector is shifted to the Call Mode by the Start-Of-Message code; out of the Call Mode by the End-of-Address code, or the End-Of-Message code.
- **Print Mode (P)** — In this mode the receiving equipment will copy line signals. The selector is shifted to the Print Mode by the Station Selector and End-Of Address codes; it is shifted out of Print Mode by the End-Of Message code
- **Invite Mode (I)** — The selector must be in this mode in order to respond to the invitation to Send Code The selector is shifted to the Invite Mode by the Invite Initiate code and remains in the Invite Mode until receipt of any next character.

Control Codes

The control codes offered to customers using Plan 117-B or Plan 137-A are shown in Figure 4.

- **Start of Message (S.O.M.)** — Shifts selector to call mode and stops any transmitter which may be sending. The S.O.M. code is usually a single character. In Plan 117 B, the selector will respond to this character only when it is in the select mode
- **Station Selector Code (S.S.C.)**—Generates the answer back code if the receiving equipment has ample supply of paper or tape and its motor is running; conditions the selector to shift to the Print Mode upon receipt of the end-of address character. A single character may be used as the S.S.C.; up to twenty single characters are available in the Plan 117-B, and 26 in the Plan 137 The selector will respond to the S.S.C only when it is in the Call Mode.
- **End of Address (E.O.A.)**—Shifts selector out of the Call and Select modes, and into the print mode if the S.S.C. has been received by the selector. Restarts any transmitter stopped by the S.O.M. A single character may be used as the E.O.A.
- **End of Message (E.O.M.)** — This shifts the selector into the select mode and out of the print and call mode. It is a single character in Plan 137-A, and a sequence of two characters in Plan 117 B. The E.O.M. code must not be

	CONTROL CODES		PLAN 117-B	PLAN 137 A
	S.O.M	Start of Message	W	S.O.M
2	S.S.C	Station Select Code	ONE OF 20 CHARACTERS AVAILABLE	ONE OF 26 CHARACTERS AVAILABLE
3	E.O.A	End of Address	SPACE	E.O.A
4	E.O.M.	End of Message	FIGS-H	E.O.M
5	I.I.	Invite Initiate	FIGS-Z	S0
6	S.C	Send Code	SAME AS S.S.C	SAME AS S.S.C
7	E.O.T.	End of Transmission	FIGS S	E.O.T
8	S.L.A.	Send Line Alarm	FIGS-Z BLANK	S6
9	A.B.	Answer Back	V OR M	ACK
10	B.C	Broadcast	W Q	S.O.M. O
11	T.D.	Transmitter Disconnect	FIGS-Z LINE FEED	S7

Figure 4. Control Codes for Plan 117-B and 137-A

used in the text of a message except to perform the functions indicated above in the selector. In some systems the processor will respond with the T.D. code in response to the E.O.M. code.

- **Invite Initiate (I.I.)** — Shifts selector to the Invite Mode and out of the Print Mode until the next character is received by the selector. The I.I. code is a two-character sequence, the first being the character "Figures," in Plan 117-B; a single character in Plan 137. **This code must not be used in the text of a message.**
- **Send Code (S.C.)**— If the selector has a request to send, the transmitter will start sending; if no request to send has been stored, then the selector will generate the A.B. code to indicate that it has no traffic to send. A single character will be used for the S.C., usually the same character used for the S.S.C. The selector will respond to this code only if it is in the Invite Mode.
- **End of Transmission (E.O.T.)**—This control code will be used in systems where more than one message may be sent during one transmission. The processor will generate the T.D. code in response to the E.O.T.
- **Send Line Alarm (S.L.A.)** — Stops and disconnects transmitters from the line; also operates a visual and audible alarm at a station in the process of transmission. A single character is used in Plan 137 and a sequence of three characters are used in Plan 117-B for the S.L.A. code. **The S.L.A. code must not be used in the text of a message.**
- **Answer Back or Acknowledge Code (A.B.**—Single character, a "V" or "M" in Plan 117-B, "ACK" in Plan 137. The character is generated by the selector as a response to an S.S.C. or an S.C. code.
- **Broadcast Code (B.C.)**—Conditions the selector to shift to the Print Mode upon receipt of the end of address code. A two character sequence will be used, the first being the S.O.M. code.
- **Transmitter Disconnect (T.D.)** — Stops and disconnects the transmitter from the line if the transmitter is sending. A single character is required in Plan 137 and a sequence of three characters in Plan 117-B is used for the T.D. code. **The T.D. code must not be used in the text of a message.**

Control character sequences used in the Control Codes, must never be interrupted.

Sending to Way Station

Figure 5 is a flow chart showing the steps in sending a message from the processor to a way station. The following message format will be used

(S.O.M.) (S.S.C.) (E.O.A.) (TEXT) (E.O.M.)

The W.S.S. will normally idle in the non-print, Select Mode. The processor will first transmit the S.O.M. code. Receipt of the S.O.M. at the way stations will shift the selectors to the Call Mode and stop any transmitter which may be sending to the control station. The processor will then wait until it recognizes a marking line condition on its receive leg. In assuring that any activity in its receive leg has stopped, the processor must consider signal propagation delays.

After assuring that its receive leg is idle, the processor will generate the way station's S.S.C. and wait for the A.B. code from the way station. Receipt of the S.S.C. at the way station selector will generate the A.B. code, if the receiving equipment has ample supply of paper or tape, its motor is running and the equipment is not in the "out-of-service" mode. The processor should wait at least two seconds for the A.B. from the outstation.

If no A.B. is received, then the processor will generate the E.O.M. code. The E.O.M. code will restore the selector to the Select Mode and restart any transmitter stopped by S.O.M. The processor may send the S.S.C. twice before it generates the E.O.M. code. Upon receipt of the A.B., the processor will then generate the E.O.A. to shift the selected way station to the print mode. The E.O.A. will restart any transmitter that was stopped by the S.O.M. The E.O.A. will also shift all Way Station Selectors out of the Select and Call modes to prevent read-

ing for S.S.C. characters during the text of the message.

The processor must not generate any I.I. or S.C. codes between the S.O.M. and E.O.A. codes. During the reception of text the way station may receive the Invite Initiate and Send codes. The I.I. code will not print nor space on the receiving equipment and will shift the selector out of the print mode for one character to prevent spacing or printing of the S.C. at the outstation. At the end of the message the processor will generate the E.O.M. This will shift the called W.S.S. out of the Print Mode and shift all WSSs to the Select Mode.

An out-of-service switch is provided in the W.S.S. control panel. When it is necessary to replenish the paper or tape supply of the receiving equipment, this switch will be operated to the out-of-service position. This will prevent generation of the A.B. code upon selection.

If while receiving a message, the way station receive leg is opened (spacing condition), then the selector mode will not be affected and the receiving equipment will run open to indicate failure of the facility.

Multiple Addressing

By use of multiple addressing, any number of way stations on the circuit may be selected to receive the same message and an Answer Back will be required of each to assure receipt of the message.

A typical message format would read as follows: (S.O.M.) (S.S.C. First Station) (S.S.C. Second Station) (E.O.A.) (TEXT) (E.O.M.) A special Broadcast Code may be used to call-in all stations on a broadcast message. This code will be a two character sequence to which all selectors in the Select Mode will respond. All selectors will then be shifted to the Print Mode upon receipt of the E.O.A. There will not be an Answer Back from the outstations upon receipt of the Broadcast Code. In multiple addressing, if at least one of the called way stations answers back, the message should be transmitted. After transmission to the answering station, the processor will attempt to select again the stations which did not answer and resend the message.

"Polling" the Way Station

The processor is continuously inviting the way stations to send. It does this by generating the I.I. and the S.C. codes of the way stations. This combination of control codes is normally referred to as the I.T.S. (Invitation-to-Send) code. The I.T.S. codes are continuously transmitted by the processor in a predetermined polling pattern.

Prior to sending each I.T.S. code the processor must check to determine that its receive line is idle, as shown in the flow chart in Figure 6. It will then monitor its send line. If it determines that the condition of the line is as follows, it will take the indicated action:

Idle — When the processor is not sending to a way station, then the processor will generate an I.T.S. code.

Busy — If the processor is sending to a way station, the processor will check to assure that it is not sending a message preamble or a control code sequence. If this condition is met, the processor will then delay its transmission a variable time, then send an I.T.S. code. This variable transmission delay time will prevent continuous interruption of the send line, by I.T.S. codes. After the I.T.S. has been transmitted the processor will continue to send its interrupted message.

After transmitting the I.T.S. code either of the following will occur:

1. Invited station receives I.T.S. but has no traffic to send. It will indicate this by transmitting an A.B. code to the processor.
2. Processor does not receive traffic nor A.B. code on its receive leg for 2 seconds. The processor will operate local alarm or notify supervisor at processor that a station failed to respond.
3. Processor receives traffic from the invited station.

After any of the three above, the processor will continue to poll the way stations as explained above.

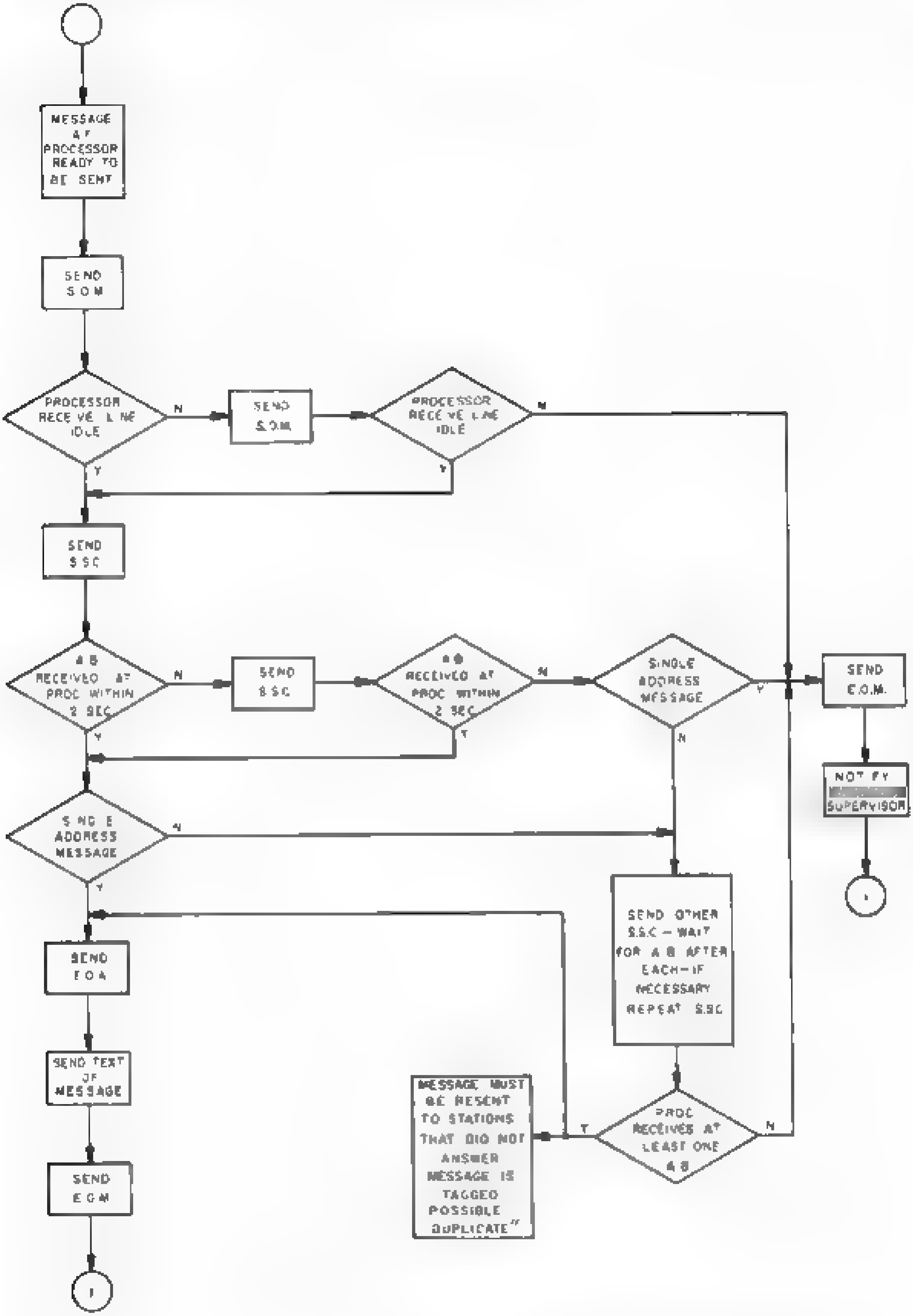

Figure 5. Flow Chart Showing Steps in Sending a Message to a Way Station

Sending from the Way Station

Figure 6 illustrates the steps in sending a message to the processor from the way station. The following message format will be used:
(5 LTRS) (E.O.A.) (TEXT) (E.O.M.) (15 LTRS)
("LTRS" is used in Plan 117-B, "Rub Out" is used in Plan 137-A)
The way station operator prepares a tape using the above format. The tape will be inserted in the transmitter, the transmitter will be placed in the run condition, and the "request" toggle switch in the control panel will be depressed. This will store a request-to-send condition in the Way Station Selector and also operate the "request" lamp (amber). Upon receipt of the invitation-to-send (I.T.S.) sequence at the way station, the "send" lamp (green) will operate and the transmitter will start sending to the processor. The E.O.A. will indicate to the processor that the text of a message will follow. Receipt of the E.O.M. at the processor will cause it to interrupt its transmission if any, and generate the T.D. Receipt of the T.D. at the way station will stop the transmitter and disconnect it from the line. If the transmitter runs out of tape before the T.D. is received, the transmitter will be stopped and a local alarm operated. The "request" and the "send" lamps will remain operated until the transmitter is stopped and disconnected. In the operation described above, only one message may be sent to the processor each time the station is invited to send.

The following format may be used to send more than one message to the processor during one transmission from the outstation:
(5 LTRS) (E.O.A.) (TEXT) (E.O.M.) (5 LTRS) (E.O.A.) (TEXT) (E.O.M.) (E.O.T.) (15 LTRS)
In this method the processor will generate the T.D. to stop the transmitter, only upon receipt of the E.O.T. code from the outstation, disregarding the E.O.M. codes used to separate the messages. The "auto-send" feature precludes the need to push the "request" toggle switch after each transmission. This is used when a continuous tape with more than one transmission is sent. For this operation at least fifteen LTRS (throwaway) characters are needed between the transmission as follows. For single message on each transmission:
(5 LTRS) (E.O.A.) (TEXT) (E.O.M.) (15 LTRS) (E.O.A.) (TEXT) (E.O.M.) (15 LTRS)
For multi-messages on one transmission:
(5 LTRS) (E.O.M.) (TEXT) (E.O.M.) (5 LTRS) (E.O.A.) (TEXT) (E.O.M.) (E.O.T.) (15 LTRS) (E.O.A.) (TEXT) (E.O.M.) (5 LTRS) (E.O.A.) (TEXT) (E.O.M.) (E.O.T.) (15 LTRS)
The fifteen letters are required to allow enough time for the processor to respond to the E.O.M. or E.O.T. and send the T.D. to stop the transmitter, before it sends the E.O.A. of the next message. The tape is inserted in the transmitter and the "request" toggle switch is positioned in the "auto-send" position. The request lamp will be operated.

Receipt of the I.T.S. sequence will start the transmitter, and operate the "send" lamp. Upon receipt of the T.D. from the processor, the transmitter will be stopped and the "send" lamp will be extinguished. the "request" lamp will remain operated to indicate that a new request-to-send has been stored. During transmission of the last message in the tape, the request toggle switch should be returned to its normal position to preclude a false start after the last message has been transmitted.

Sending Alarms

During transmission of a message, the tape may be stopped due to abnormal on line or local conditions.

Local conditions include tight tape or torn tape. A tight tape or torn tape condition will cause the operation of a visual audible alarm which will stop the transmitter. On-line conditions include a receive-open-line at the outstation. In this case the selector, detecting an open line of approximately 250 ms. long, will operate the visual audible alarm to stop and disconnect the transmitter.

In each of the above cases the trans-

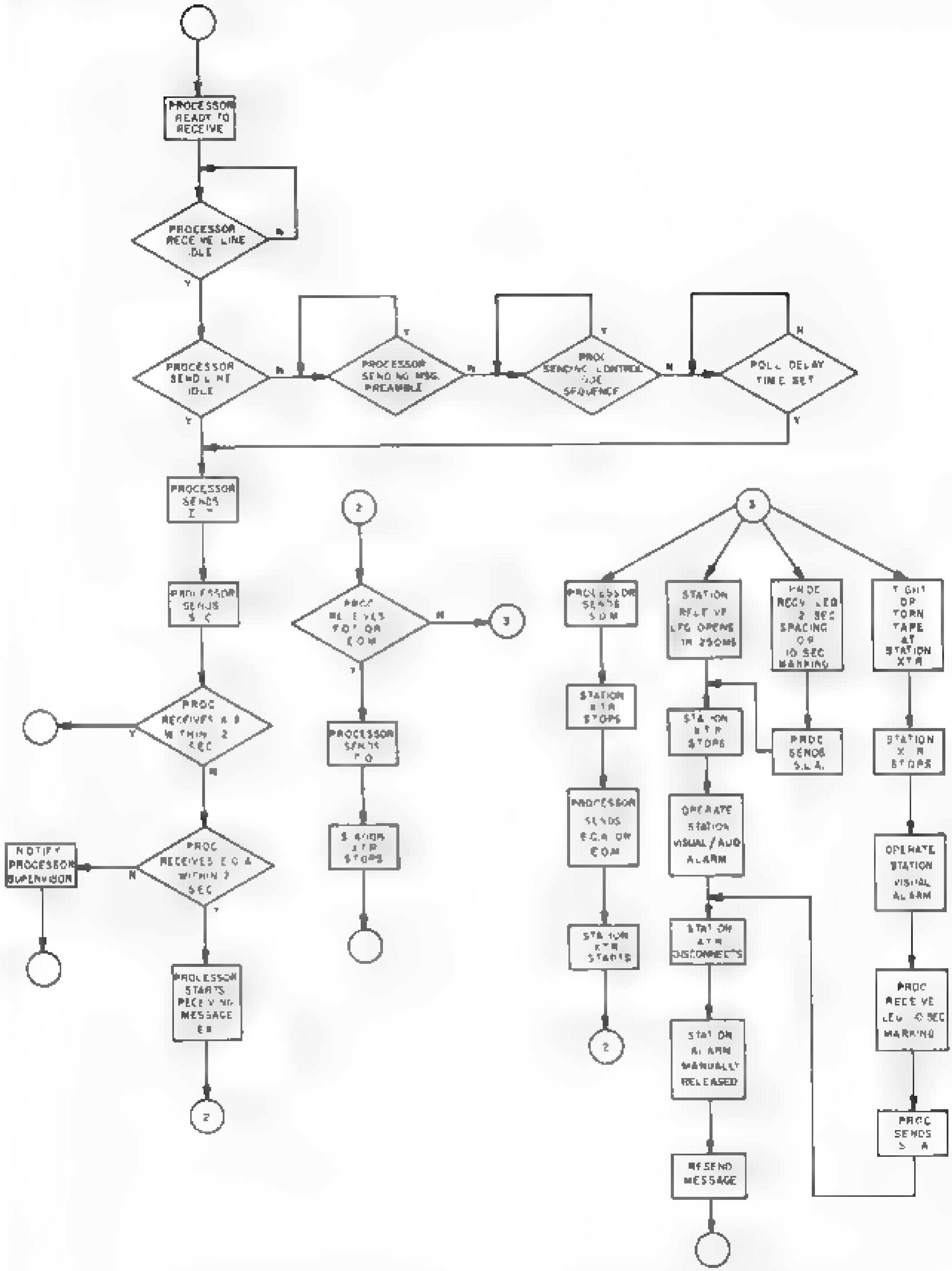

Figure 6. Flow Chart Showing Steps in Sending a Message from a Way Station

mitter stopped sending and since the processor did not receive the E.O.M. or E.O.T. and detects an idle receive line for 10 seconds, it will generate a Send Line Alarm (S.L.A.) which will disconnect the transmitter from the line. If the processor detects an open receive line, it will generate the S.L.A. to operate the alarm and stop the transmitter. In any case where the visual/audible alarm is operated at the outstation, the operator will wait until the "send" lamp is extinguished by the S.L.A. received from the processor; release the alarm condition and extinguish the alarm lamp by depressing the alarm release switch, make a new "request-to-send" and resend the entire message. The processor may send the S.L.A. code at any time it wishes to stop the transmitter and operate the way station local alarm.

Optional Features

The following optional features are offered with the Way Station Selector:

1. **Generating discreet characters from way stations.** An Electronic Modification Kit 12242 may be added to the ECC 11704 to provide a sending distributor and facilities to program up to ten discreet characters which may be transmitted serially on-line in response to control characters. This feature is possible in both the Plan 117-B and Plan 137-A. Applications of this modification kit include the following:
   a. Upon receipt of the I.T.S., the EMK will generate six discreet characters which may be the station identification code, message preamble or other fixed data. The transmitter will then be automatically started to send the text of the message. When a tape out condition is detected, the EMK will generate an End of Message sequence of four discreet characters.
   b. Upon receipt of the S.S.C. the EMK will generate discreet characters to indicate local status of the receiving equipment at the way station, such as: low paper, low tape, ready-to-receive, off line, out of service, etc.

2. **Local transmitter stop and off-line idling of throw-away characters between messages.** Where the auto-send feature is a requirement, it is necessary to stop the way station transmitter after each transmission and before the next message preamble moves to the reading pins of the transmitter. In the discussion of the standard Plan 117-B, it was stated that a minimum of 15 throw-away characters are required between the E.O.T. and the S.O.M. in order to allow the processor sufficient time to respond with the T.D. and stop the transmitter before it begins transmission of the next message preamble.

   An Electronic Modification Kit, 12509, may be added to the ECC 11704 to provide means for reading the E.O.T. when it is sent from the transmitter and to idle any subsequent throw-away characters off-line until the next message preamble is detected.

   This EMK will read the E.O.T. locally and immediately disconnect the transmitter from the line, precluding the need for having the processor send the T.D. to stop the transmitter.

   Only one throw-away character is required between messages, if others are required to move a message from the perforator to the reading pins of the transmitter, these throw-aways are idled off-line, without any waste of line time.

   This EMK is currently available only for the Plan 117-B and the E.O.T. that it reads is the sequence LTRS BL, BL-LTRS, or single BL as desired by the particular customer.

3. **Automatic Request-to-Send upon preparation of a complete message.** An Electronic Modification Kit 12510, may be added to ECC 11704 to provide a means for automatically storing a request-to-send, upon preparation of a complete message. This precludes the need to depress the request button when the way station is ready to send a message, and also prevents a tight-tape condition. A counter with manual control and visual display is provided to store up to ten requests-to-send, when ten messages are queued at the trans

mitter. As each message is transmitted, the counter will automatically subtract one until all messages are sent and then the request to send will be disabled. This EMK is available for the Plan 117-B only and is used in conjunction with EMK 12509.

4. **Line buffer to allow receipt of clear text messages at reperforator way stations.** (Required at all reperforator way stations.)

An Electronic Modification Kit 12316 may be added to the ECC 11704, to delete control characters from the message text received at reperforator way stations.

The processor may generate I.T.S. codes during transmission of a message to a reperforator. The EMK will monitor the line and prevent any I.T.S. characters from being received by the reperforator. This EMK is required only at Plan 117 B outstations since the system uses three character sequences for the I.T.S. codes, and the first character is the valid text character "FIGURES."

In Plan 137-A a two-character sequence is used for the I.T.S. but the first character is a unique control code not used in the text of the message. An electromechanical modification kit is added to the Model 35 Reperforator to prevent perforation of this character and the succeeding character.

5. **Receive parity check.** (Plan 137-A only)

A parity card may be added to the ECC 11704. When a wrong parity count is detected by the WSS, the next character is transformed into the ASCII Code character @. The type box of the Model 35 Typing Unit is equipped to print a symbol (←) instead of the @ symbol to indicate that the previous character was not received with a correct even parity count.

Only one EMK may be added to the ECC 11704, except for the EMK 12510 which must be added in conjunction with the EMK 12509.

Design Considerations

There are two basic design considerations required in the development of the Way Station Selector: the I.I. Control Code and the method used to stop the transmitter.

a. *The I.I. Control Code*

In the control of a full duplex way circuit the controls required to select the receiving equipment to copy a message are not difficult to attain, and are similar to those used in the operation of a half-duplex circuit. During the time that the way station is being conditioned to copy a message, characters received are not copied by the receiving equipment. The control characters chosen for the S.O.M., the S.S.C. and the E.O.A. may be valid message text characters which will perform certain functions in the WSS, only when it is in the select, non-print mode.

However, the characters used in the control of the way station transmitter must be unique, non-printing, non-spacing characters which when received by a way station in the print mode, will not affect the text of the message.

In the Plan 137-A this is not difficult, as this type of control character is available in the ASCII Code. However, in the Plan 117-B this unique character, I.I. code, or control function, is obtained by resorting to some artful dodges. In some duplex way selectors a "timed" marking line condition is used to indicate to the WSS, that the character that follows is an invitation or polling character; others use a BLANK all spacing character.

In the Baudot Code the only character which may be considered redundant is the "LF" character. In almost every instance the "LF" character is transmitted in conjunction with the "CR" character. If a system uses the automatic "CR-LF" function at its receiving equipment then it will automatically carriage return and line feed upon receipt of the "CR" character, precluding the need for transmitting the "LF" character. The "LF" character may then

be deleted from the text of every message, and it may be used as the unique control character. When received at a way station, it will not affect the text of the received messages. This method has been successfully used in a computer controlled Plan 117 system. It has the advantage of using a single character for the I.I. code. Messages which may generate from another system must be processed by the computer before they are transmitted to assure that "line feed" characters are deleted from the message text. In this system the length of a printed line is limited unless a throw-away character is added after each "CR" to allow enough time for the printer type box to return to the left hand margin of the paper.

In recent installations of Plan 117 B systems a sequence of two characters have been used as the I.I. control code. The first character is a "FIGS", the second, an upper case symbol which is not used in the text of the massage. Sequences such as "FIGS-Z" or "FIGS-S" have been used.

This method requires that the receiving equipment be restored to its original condition (lower case or upper case) after the complete I.T.S. sequence has been received. The stunt box of the Model 28 Teleprinter is used to mechanically perform this function at the way stations. Since this method does not place additional burden on the processor, it has been favorably accepted and is being used satisfactorily in most recent Plan 117-B systems.

This sequence of two characters does not affect the printed copy and also conditions the WSS to delete the next character from the printed copy. It can then be used as the prefix for the T.D., or S.L.A. control characters. Consequently, if FIGS-S is the I.I. code then FIG-S-LF may be used for the T.D., and FIG-S-BL may be used as the S.L.A. These characters may be transmitted by the processor during the course of a message without mutilating the copy received at the way station.

b. *Stopping the Way Station Transmitter*

Normally the transmitted signals from the transmitter (LXD) on a duplex circuit are not monitored by the Way Station Selector since it is always monitoring receive leg signals. This precludes stopping the transmitter by the W.S.S. as the E.O.T. code is sent from the LXD.

Any one of three methods may be used to terminate transmission, depending on the system requirements.

A. Torn Tape Method—Each transmission is punched on single separate tapes. The end of each message will include the E.O.M. code followed by a minimum of five throwaway characters which allow the "tapeout" pin on the LXD to operate (open) after the E.O.M. is sensed and transmitted to the line. This method precludes using the "tape out" pin to indicate an abnormal condition while sending, such as tear on the tape. This method also precludes use of the "auto-send" feature of the W.S.S. and the use of continuous tape transmission. However, this is the simplest means of stopping the transmitter at the end of a message.

B. Stopping by Processor — Receipt of the E.O.T. signal at the processor will generate the T.D. signal back to the way station. The W.S.S. will read the T.D. and stop the transmitter. This method requires that throw-away characters be inserted in a continuous tape between the E.O.T. of a message, and the S.O.M. of the next message on the tape. These throw-away characters will allow sufficient time for the processor to read the E.O.T. and respond with the T.D. to stop the transmitter. This method is recommended in the Plan 117 B and Plan 137 A. It allows for continuous tape operation and for use of the "tape-out" pin for abnormal conditions. The T.D. read by the W.S.S. may also be considered as an acknowledgment that the processor received the complete message.

C. Read E.O.T. Locally—Electronic Modification Kit 12509 provides a means for reading the E.O.T. code as it is transmitted from the LXD, and stopping the transmitter. The advantages of this method is explained above under Options.

Applications

Plan 117-B and Plan 137 A have been used to provide communications networks for patrons engaged in a wide range of businesses. These include the service, manufacturing and stockbroker industries. The systems implemented have used the Western Union 11709 Control Center, Western Union-owned computers or customer-owned computers to control the circuits. In some cases the Western Union 11709 Control Center has been used as a "back-up" to the computer.

Typical applications of the Plan 117-B and Plan 137 A dedicated systems have operated the W S.S. with the General Electric Datanet 30, CDC 8090, and IBM 360 computers. Current plans for new installations will use the W S S. with the Honeywell CCC DDP 124, and UNIVAC 418 Computers in shared-computer systems. For these shared systems new innovations for the W S S. have been developed, among these are new transmitter controls which provide means for acknowledging valid receipt of a message at the computer, before the next message is sent from the way station.

In the standard Plan 117-B operation, the computer will continuously invite the way stations to send. In these new applications, in order to further economize line time and computer work load, the computer will invite stations to send only after one of the way stations has indicated that it is ready to send a message. Additional controls were developed and added to the W.S.S. to provide a means for automatic generation of a "poll-request" signal when the way station is ready to send a message.

Plan 117-B and Plan 137 A have great versatility and can be adapted to meet the demands of any new system

In the final analysis, the function of a communications system is to transmit information between two points, by those means which stress simplicity of design, speed, and economy in operation.

The Plan 117-B and Plan 137 A have demonstrated Western Union's capability to pursue these goals and attain their successful implementation.

A. A. Ortiz a Senior Engineer in the Information Systems and Services Department is responsible for the design and application of private wire communications systems to meet specific patron's requirement. He was concerned with the development and design of electro mechanical way station selectors and the packaging of selector components

Mr Ortiz joined Western Union in 1956 and has been a major contributor to the development of Plan 115 and its applications. He was responsible for the original concept of Plans 117 and 137 and has been involved with the applications of these systems to computer controlled communications sub-systems.

He received his BS Degree in Mechanical Engineering from Brooklyn Polytechnical Institute. Currently attending a 26-week evening course in computer programming. Mr Ortiz has a patent for an attachment to the Model 28 Teletype Printer

computer-controlled communication subsystems

by J. E. Caldwell

Western Union has been actively engaged in providing private wire record communications systems in particular message switch systems since the late 1940's. These systems were provided for commercial as well as military and civil government application. In the past fifteen years these message switch systems reflected the changes in the technological state of the art. Customer requirements and the economic competition resulted in the design of systems that varied greatly in cost and in operation. The systems ranged from manual torn tape and plug-and-cord systems utilizing relay technology to fully automatic routing systems utilizing solid state technology. No matter how sophisticated the design of these systems their basic dependence on paper tape as a storage media and on electromechanical readers and perforators limited their flexibility; thus, it was impossible to adapt them to meet the demands of modern-day data communications without incurring exorbitant costs.

Since the early 1950's it has been evident that the digital data processor would play a major role in communications. Subsequent technological breakthroughs in the digital field, the phenomenal growth of data and the demand for on-line and real-time systems provided the necessary impetus. By early 1960 the trend started toward the application of data processors as message switch controller elements.

Computer Message Switch

By the early 1960's data processors were replacing the electromechanical paper tape message systems as the controller element. The significance of this and the fact that practically every computer has the potential for message switch application is having a tremendous impact in the data communication field. Western Union, in keeping with the demands of modern data communication and with the introduction of the computer, is meeting the competitive and technological challenge in a number of ways. The dedicated message switch systems offered by Western Union are now designed around a computer as the controller element. In addition a standard line of systems and equipment which are computer control oriented, have been developed which are capable of interconnecting with Western Union or customer provided computers or terminals.

Communications/Computer System

The use of the data processor as an on-line communications message switch controller presents a problem different from the normal application of a data processor system. Normally, a computer has the task of processing data on a batch basis in a scheduled environment. Conversely, a dedicated message switch system involves a constant data flow at low speed over a number of lines with variable message loads.

All sub-systems interfaced with a computer gain access through the high-speed input-output channels of the computer. The transfer of data between the computer and the peripheral subsystem is accomplished by a parallel transfer of one or

more characters at very high clock rates. The communication sub-system basically operates in the same manner. Most communication subsystems operate under program control and require a reference or program interrupt for each transfer. A message switch operates in a real-time environment, therefore, the communication subsystem to be effective must be able to interface with a large number of simultaneously operating lines of mixed speeds and be able to transfer all characters received without the loss of characters and also without impairing the efficiency of the computer by needless program interrupts.

Communication subsystems, while operationally similar to other peripheral subsystems, are very costly. In some systems the cost of the communication subsystem is a substantial part of the total system cost

Interface Implementation

The simplest way to interface a subsystem with communication lines is the bit buffer approach. The computer with this approach has the task of assembly of the bits into characters and the disassembly of the characters into bits for transmission. While the hardware cost for this subsystem is minimal, there is a substantial waste of computer time and lack of efficiency.

The method used by most subsystems for communication interface is based on double character storage and transfer to a computer. The incoming low speed communication lines operate on a serial basis, bit by bit and character by character. Figure 1 illustrates character assembly for transfer to a computer. A serial to parallel register in the subsystem stores the character, then the character is transferred on a parallel basis to the next character storage register and from here it is transferred on a parallel basis under program control to the computer Characters from the computer to the lines are treated in the same manner. The costs of this arrangement could be substantial because of the two character buffering required on a per line basis

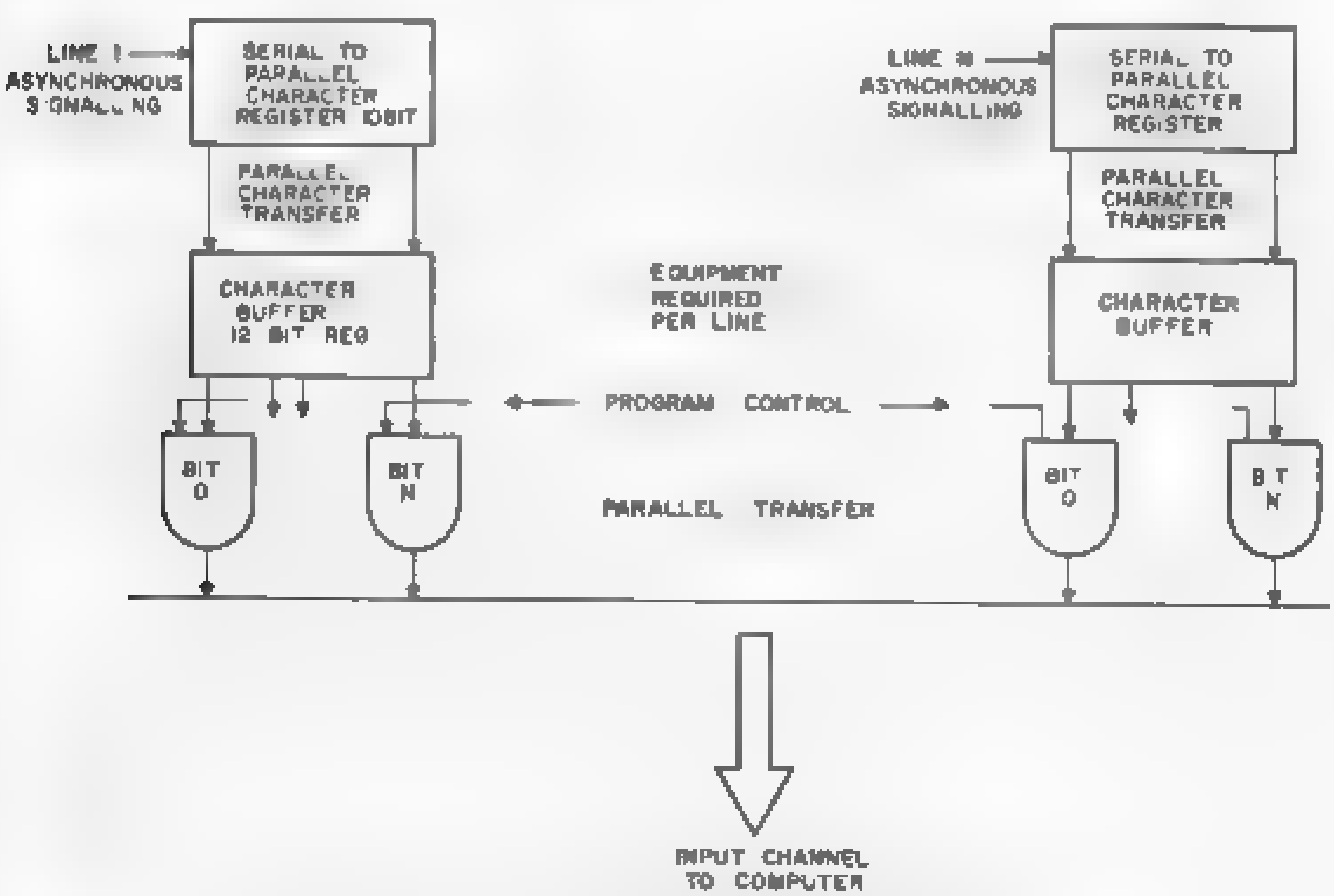

Figure 1. Character Assembly for Transfer to a Computer

Another approach used by very large and efficient systems is one, where the communication subsystems is a preprocessor with hardware and/or software programmable features and which has the ability to transfer to the computer more than just one character at a time. This is a much more expensive approach

It is noted that the choice of the selection of interface must be based on trade off studies involving programming and execution tasks of the computer and hardware costs of the communication subsystem

Communication Subsystems

Western Union's first operational computer oriented communication subsystem utilizing time division techniques is the Communication Multiplexer, Concentrator 11922, shown in Figure 2, designed for interfacing digital communication lines with the Control Data Corporation Computers 160 and 8090. The system was designed in modular form so that by the addition or removal of some of its modules the system could be used on site with the host computer or remote from the computer as an asynchronous multiplexer.[1,2]

When the multiplexer is operated remote from the computer, it basically operates as a sub-system, as shown in Figure 3. It accepts asynchronous signals from a number of full or half duplex circuits These signals are assembled on a double character basis technique and transferred to a high speed buffer register where they are transmitted serially bit by bit by character-by-line to a Western Union modem, where the direct current signalling is converted to tone signalling over a four-wire system. The high speed four-wire system is terminated in an on site modem. The tone signalling is then converted back to direct current bi-polar signals and fed at high speed into the on-site multiplexer without the need of dechannelizing. Operation from the computer to the remote multiplexer is accomplished in the same manner except that the outgoing signalling is under program control

It should be noted that the double character assembly and disassembly was accomplished by the data flow method as indicated in Figure 1

The character registers in this multiplexer are made up of core elements and all of the logic circuits are discrete solid state components.

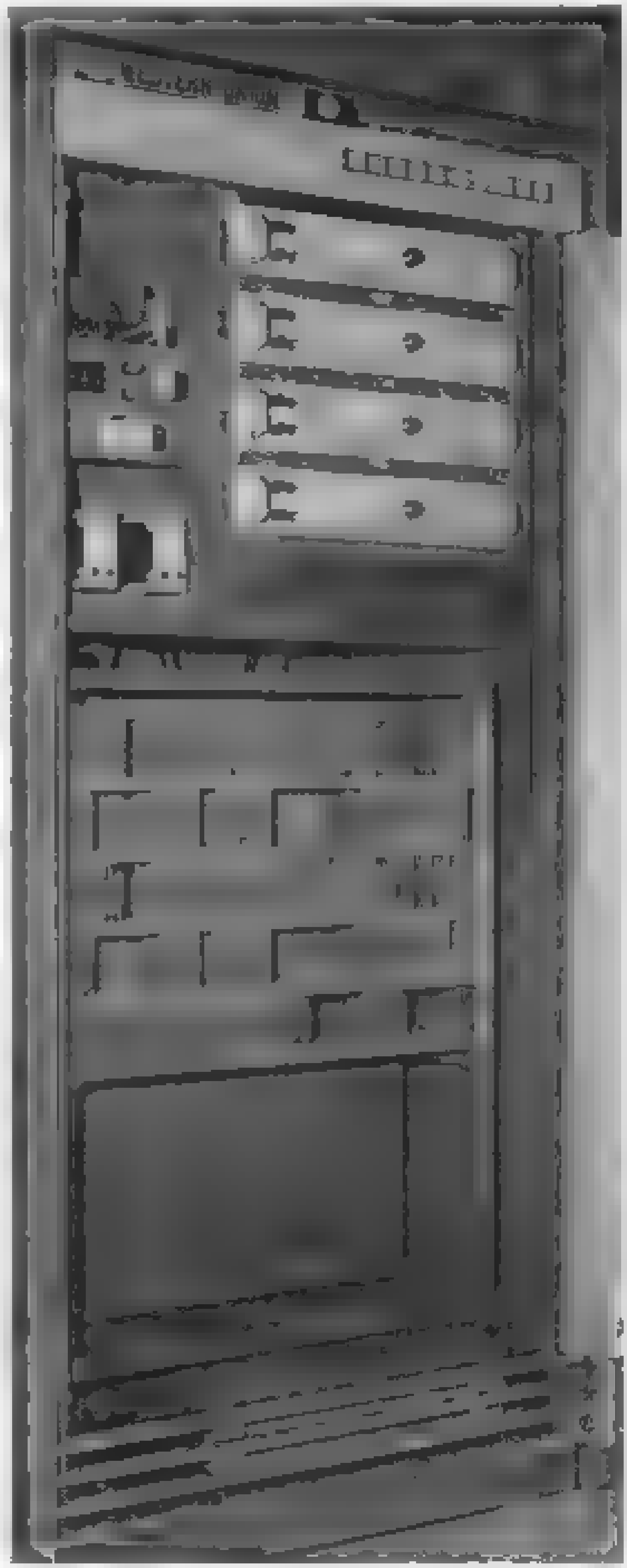

Figure 2. Western Union 24-line Multiplexer

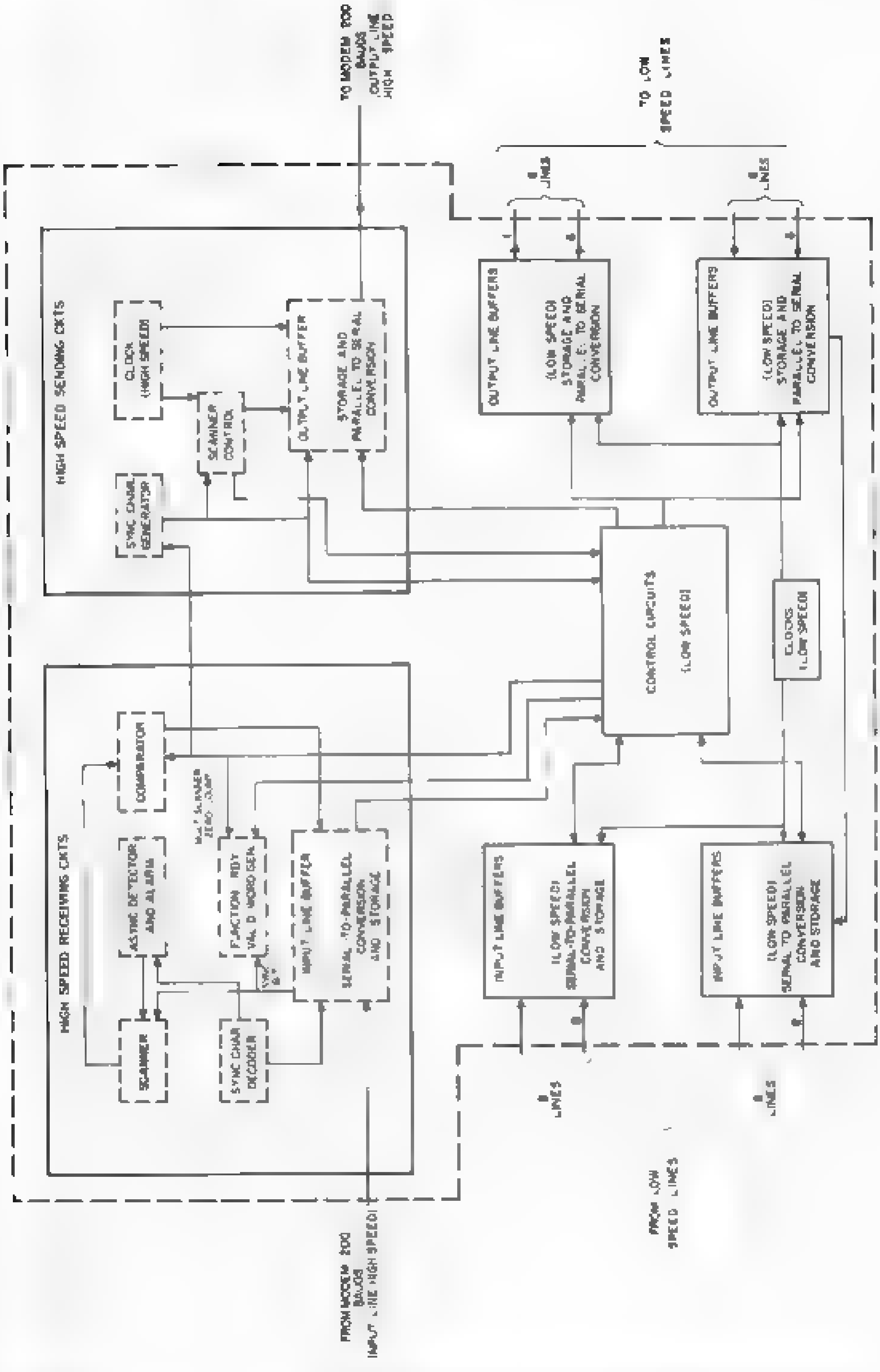

Figure 3. Communication Subsystem — Remote Multiplexer

DALCODE*

Because of the phenomenal growth of data and the trend to use data processors as message switch controllers the number of circuits in a network terminated in a single center has increased. This is due to the fact that a single computer center as a message switch controller has often replaced two or more electromechanical systems. This means that there are a large number of low speed circuits transmitting over long distances. To minimize this condition Western Union has designed a new remote time division multiplexer called DALCODE*, Data Line Concentrator/Deconcentrator. DALCODE*, unlike the previously discussed remote multiplexer, is designed around a serial storage device magnetostrictive delay line. This type of delay line consists of a coil of nickel alloy wire with an input and output transducer at each end. The input transducer converts electrical pulses to mechanical energy in the form of acoustic waves. This energy travels down the wire slower than the electrical energy to the output transducer where the mechanical energy, is converted back to electrical energy.

The actual time it takes a bit to propagate the delay line medium determines the total storage. For example, if a delay line can accept information rates up to 1 Megahertz (MHz) and the delay is 2000 microseconds, then the total storage is 2000 bits utilizing an RZ (return to zero) input coding. Unlike most storage elements data once entered into the delay line cannot be inhibited, slowed or stopped, but can be recirculated. Therefore, it is normally regarded as temporary storage.

The circuitry of the DALCODE consists of modular circuit cards. Three of these cards contain 90% of the total number of solid state components. These cards are made up of monolithic, integrated, solid-state components, such as the TO-5 type, flip-flops, and 2-, 3-, and 6 input gates. The remaining 10% of the components are discrete solid state elements. The delay line with its read-and-write amplifiers are mounted on a circuit card.

The use of integrated circuitry and the delay line as a serial storage made possible the development of a unit capable of terminating a large number of circuits economically and with reliability. A DALCODE cabinet usually houses two DALCODE units. Figure 4 shows the front view of a DALCODE cabinet.

*Western Union Trademark

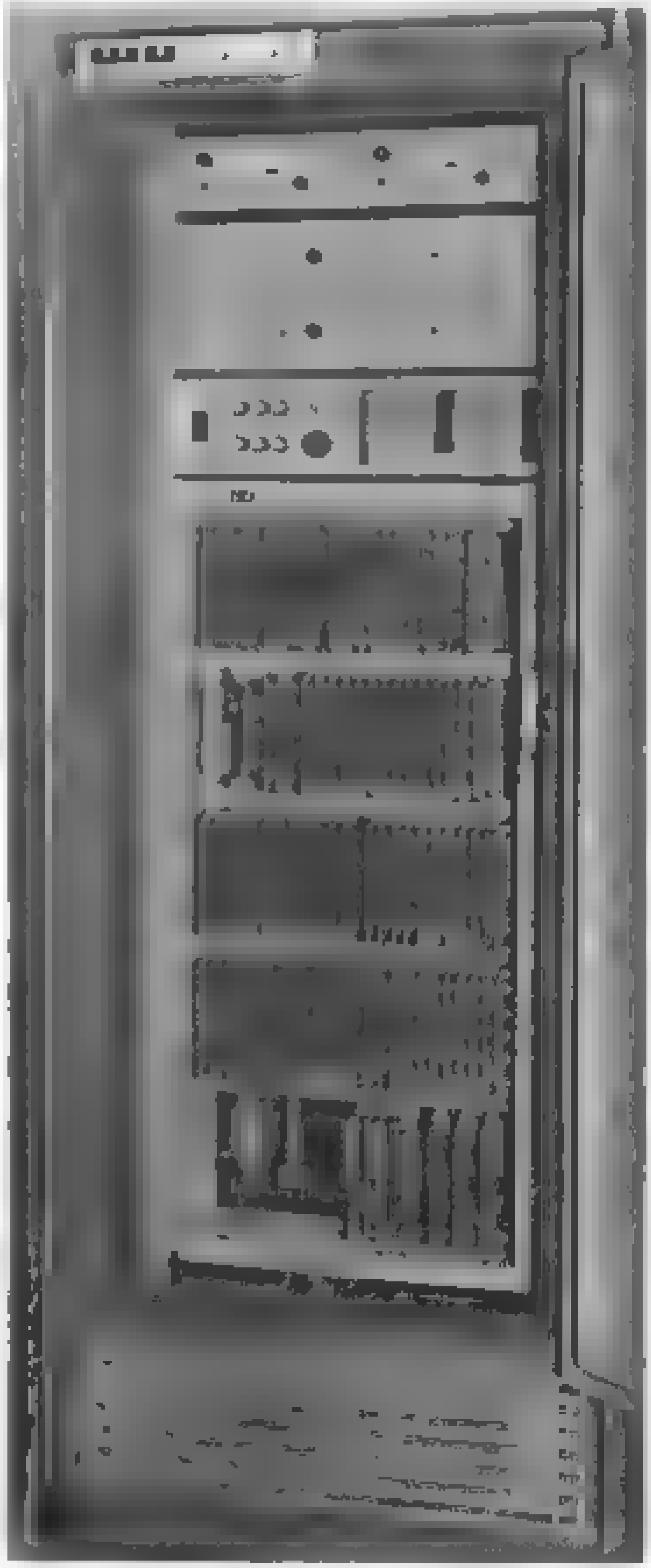

Figure 4. Front View of a DALCODE Cabinet

DALCODE Applications

The DALCODE was designed for two applications, back-to-back time division carrier system and as a computer subsystem. It is used to concentrate traffic from asynchronous communication lines having the same or different low speeds and variable character lengths which it transmits on a time division basis to a remote location over a voice grade channel synchronously at 2400 baud. For a back-to-back configuration, as shown in Figure 5, another DALCODE will dechannelize the signal at the receiving end at the same speed and character length at which it was sent. Operation in the reverse direction is identical.

The DALCODE, as a computer subsystem, is capable of operating directly into a computer without the need of a back-to-back configuration, if the computer can meet the hardware and software requirements necessary to interface with the DALCODE.

Two brokerage firms are now using the DALCODE system. These two systems have with the DALCODE a dedicated time division carrier network. One DALCODE system terminates a number of low speed way circuit systems at Los Angeles. A dedicated high speed voice grade facility, operating at 2400 baud, links the Los Angeles DALCODE located on Western Union premises with a DALCODE located in Western Union, New York City. From here low speed lines are established to the customer's premises and terminated in a patron provided IBM 2702, front end of an IBM 360. The IBM 360 is programmed to recognize the condition of the DALCODE network by characters automatically generated by the DALCODE.

Western Union is assembling a communication network for an industry oriented system which will consist completely of a time division carrier network of DALCODES which are to operate directly via a high speed link into the front end of a UNIVAC 418 Computer. This carrier system is unique in that it will utilize DALCODES as remote multiplexers.

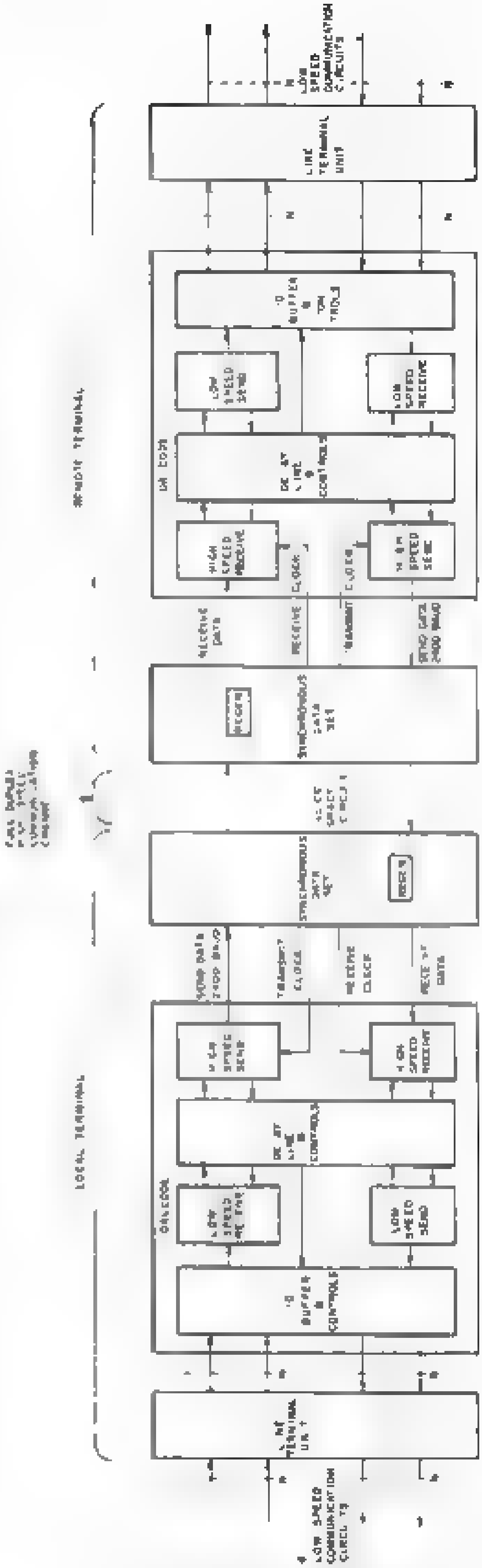

Figure 5. Back-to-Back Configuration of Two DALCODE Units

Low Speed Send Operation

Figure 6 illustrates data flow through the DALCODE. Asynchronous low speed characters from a maximum of 30 lines are serially received bit-by-bit-by-character and applied to the DALCODE input buffer and control. Utilizing a bit buffer technique these bits are synchronized with the delay line bit counter and gated into the delay line. The delay line buffers and assembles the bits into characters.

The delay line unit stores low speed characters serially in the timing slots provided by a 1 MHz system clock. This clock also steps a bit counter which identifies the various bits as they pass through the shift register for control purposes. A counter steps a sector counter which determines the line to be serviced. One line is reserved for synchronization. When N is the total number of operational lines, (N + 1) is the line reserved for synchronizing.

The high speed send circuitry accepts the character in parallel from the output shift register of the delay line and transmits this character serially to the synchronous data set, when enabled by a transmit clock pulse from the data set at 2400 baud. The sync character in the (N + 1) line is checked as an internal test and a new sync character is generated. If eight consecutive errors occur, the DALCODE is automatically switched to fallback. Odd-parity is optional; if used, the parity bit is added to the end of each character. The local synchronous data set translates the tone signalling back to low level dc signals, which are applied to the high speed receive circuitry of another DALCODE or to a computer on-site multiplexer.

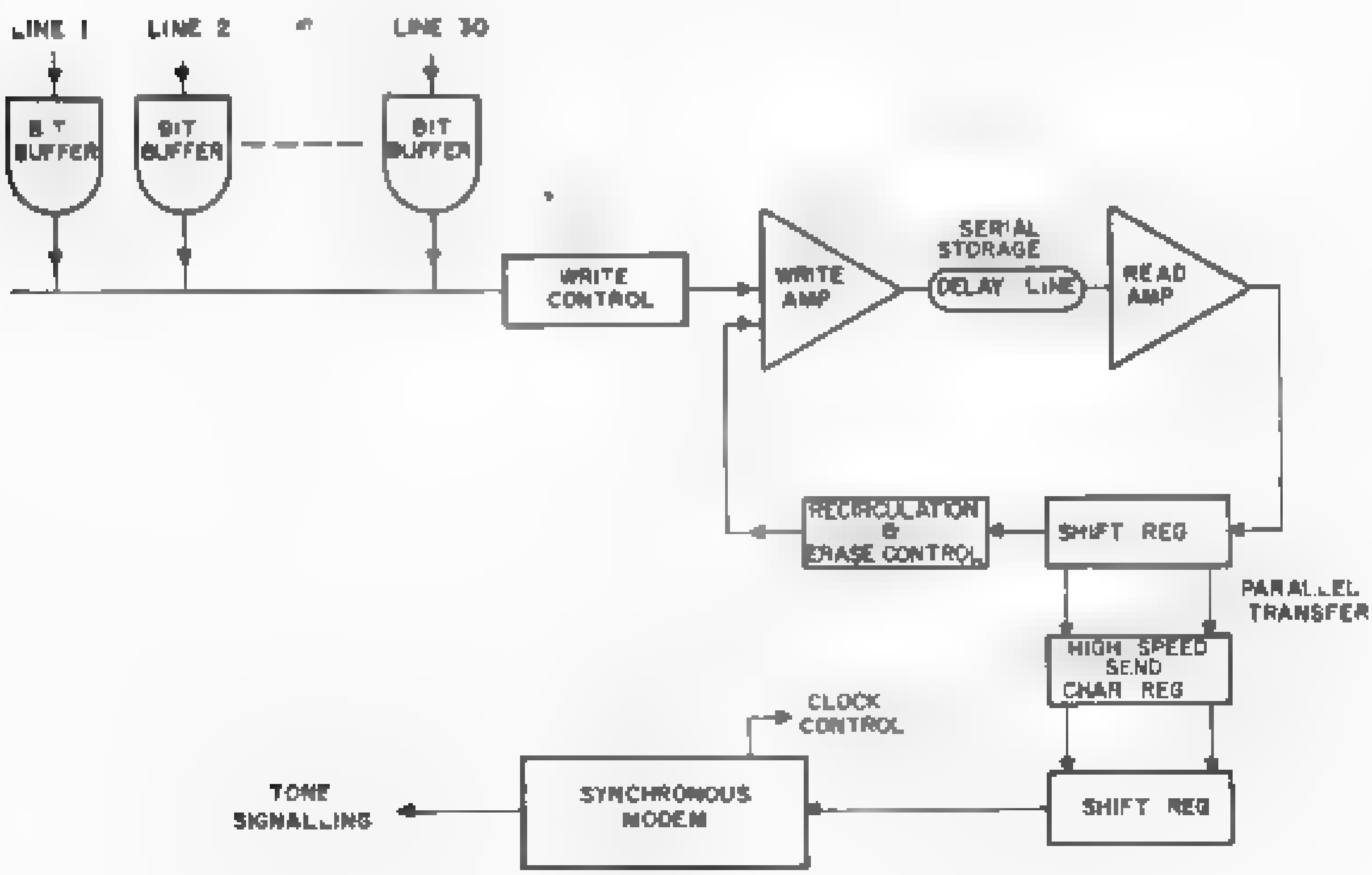

Figure 6. Data Flow through the DALCODE

Circutry

The high-speed receive circuitry synchronizes the 1 MHz clock with the receive clock from the synchronous data set to the high-speed receive shift register. Then, upon request, the data is transferred in parallel to the send input storage bin of the delay line via the parallel buffers. The associated control circuits check the sync character on the (N + 1) line to determine the incoming line relationships, and compares this line count with the sector counter to synchronize it with the data line. If parity is used, the controls check whether or not each character has been correctly transmitted. When an out-of-sync condition or parity error is detected, this information is placed in the parallel buffer for transmission to the respective outstations

The low-speed send circuitry checks the delay line and shifts the character from the send input storage bin to the send output storage bin, then transfers bits serially to the output buffer. The controls, in conjunction with the output buffer controls, restore the characters to their original length, rest pulse and baud rate.

The output buffers receive bits serially from the bit input control and gates them into their respective lines as determined by the line sector counter for transmission via the line terminal units to the outstations. Note that the same delay line is used for sending and receiving.

Advantages of DALCODE

The primary advantage of DALCODE operation is that back-to-back operation is not necessary if the on-site multiplexer and computer are hardware and software capable of terminating the 2400 baud line direct and performing DALCODE assembly/disassembly functions. Western Union provides message switch systems with DALCODE and a Western Union Communication subsystems which operate in this [illegible]

Special Features

1. Asynchronous low speed lines up to 300 baud may be accommodated.
2. Character codes 5, 6, 7 and 8 may be accommodated.
3. Up to thirty full duplex circuits may be accommodated See Table I below.
4. Bit distortion of 42% is acceptable and the output character is regenerated with no distortion.
5. An odd parity bit is added to every character when placed on the high speed line and stripped at the other end after being checked.
6. System check is provided with automatic transfer as an option to a hundred percent redundant logic gate in the same cabinet.

Table I

Number of Low-Speed, Full Duplex Communications Lines Terminated in One DALCODE at 2400 Baud

Communication Lines		Theoretical (Maximum) Number of Lines		Actual (Maximum) Number of Lines	
Speed (baud)	Length of Character (bits)	Without Parity	With Parity	Without Parity	With Parity
45.45	7.5	53	46	31	31
45.45	11.0	55	—	31	—
50.00	7.5	48	42	31	31
50.00	11.0	49	—	31	—
56.90	7.5	42	36	31	31
56.90	11.0	43	—	31	—
74.20	7.5	31	27	30	27
74.20	11.0	32	—	30	—
110.00	7.5	20	17	20	17
110.00	11.0	21	—	20	—
135.00	7.5	16	13	16	13
135.00	11.0	16	—	16	—
150.00	7.5	14	12	14	12
150.00	11.0	14	—	14	—
180.00	7.5	11	9	11	9
180.00	11.0	11	—	11	

System Capability

The theoretical maximum number of full-duplex lines that a single DALCODE can service is dependent upon the baud rate and code of the high-speed line. System capability is expressed by the following equation

$$\frac{1}{B} \times T = \frac{1}{H} \times L \times N + K \text{ or } N = \frac{TH}{LB} - K$$

where

- B baud rate of low-speed lines.
- T total bits/character of low-speed lines.
- H baud rate of high-speed channel.
- L total bits/character of high speed channel. This is equal to T rounded off to the next lowest whole number. If T equals 7.5, then L is 7; if T equals 11, then L is 10. However, if parity is used, one bit is added to L. Then if T equals 7.5, L is 8
- N = theoretical maximum number of full-duplex, low-speed lines.
- K = is a factor which reduces the theoretical maximum number of lines in order to use some lines for synchronization and internal design considerations. When one line is needed for synchronization, one to account for the low-speed clock and high-speed clock not being synchronized, and one for a safety factor, then K = 3

For example, if the low-speed input has a 7.5 unit code at 50 bauds and the DALCODE output with parity added is 8 (7.5—0.5 + 1 = 8) at 2400 bauds, and K is 3, then,

$$N = \frac{7.5 \times 2400}{8 \times 50} - 3 = 42$$

Thus 42 is the theoretical maximum

COLMUX*
Communication Line Multiplexer

Western Union's first computer communication subsystem was designed specifically to interface with a CDC computer. Its application was thereby limited.

Based upon the design experience with the CDC subsystem a new subsystem development was undertaken. This new design COLMUX, Communication Line Multiplexer, utilized monolithic integrated circuit components and serial storage, magnetostrictive delay lines. In addition, it was modular in design thereby permitting its use with any number of different computers as well as being able to interface with Western Union's DALCODE without the need of de-channelizing

A typical network configuration indicating an application of the COLMUX* is shown on Figure 8

The COLMUX* is a serially operating machine designed for normal operation on a standard computer buffer channel using serial word transfer. It can perform random word transfer by supplying an index address identifying each word

Low and high speed buffers are provided by different modular units. These are synchronous and asynchronous buffer units. A different multiplexer control and interface unit (MCI) is supplied for each different computer the COLMUX* interconnects.

The computer communication subsystem is small in size, 63 inches high by 52 inches wide and 28 inches deep.

COLMUX can operate in either of the following three modes:

Standard Sequential Mode

Lines divided into groups. When a group is selected, every line is serviced and characters transferred

Addressed Sequential Mode

To eliminate the necessity of wasting processor time by making unnecessary in-

*Western Union Trademark

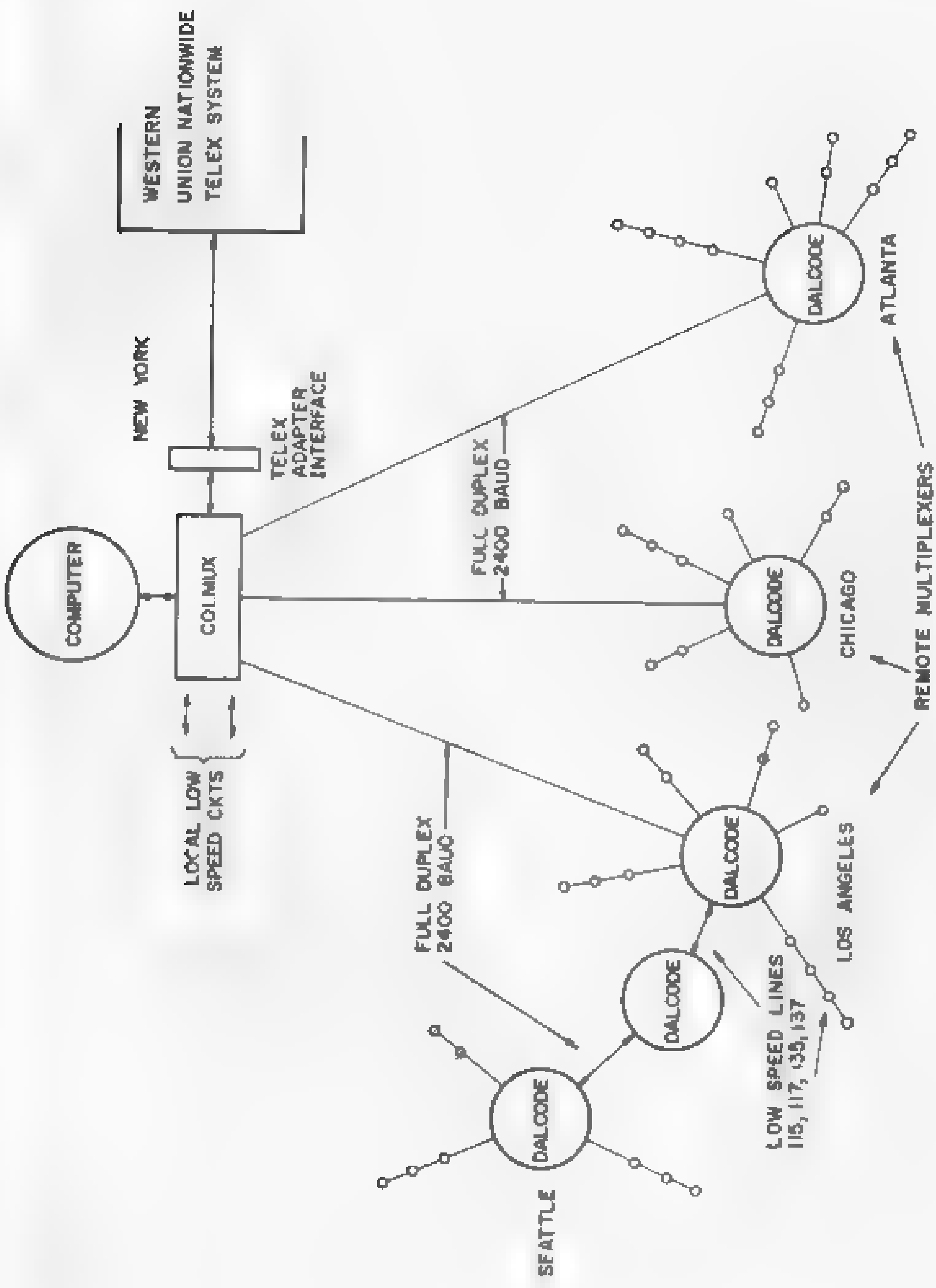

Figure 8. A Typical COLMUX Application

put or output service requests when lines are idle the addressed sequential mode is utilized. Only those lines which are busy will perform word transfers.

Random Mode

The random mode, using externally specified indexing, will allow the COLMUX to send and receive information from any number of preassigned storage areas in the processor's core memory. The index address identifying the line number and line buffer unit will be put on address line.

Line Buffer Units

Line Buffer Units are designated as ALB and SLB. The types and number of Line Buffer Units are dictated by the system configuration It should be noted that the features presented for the Line Buffer Units need not be used in every system. They represent total capability of the Line Buffer Unit; however, the system configuration will determine which features are actually used. Other modular line buffers will be designed as system requirements are firmed

Low Speed Buffer

The module can terminate up to 282 full duplex start, stop communication lines expandable in groups of 94 lines. Six different baud rates can be accommodated in a 89-line group up to 220 baud

5-, 6-, 7-, and 8 bit character codes can be accommodated. The START and STOP bits of line characters are stored and can be transferred to the processor if desired.

The unit is capable of timing for idle line (marking) conditions for periods of up to 3 seconds. A special code is then transferred to the processor

The unit can detect two consecutive open line characters (spacing) at which time it transfers a special code to the processor. As long as the open line condition remains, no further transfers will be made to the processor for this line.

In the Random Mode of operation, the unit will recognize a "Stop Requesting Output" command and cease output requests to the processor A "Start" command originated by the processor will remove the stop condition and restore normal operation

The unit can output to any line steady mark or space signals under control of the processor by use of appropriate control words.

A maximum of six speed code combinations can be used with the unit.

The unit does not check or generate parity for line characters

The ALB storage element consists of three delay lines. Two for assembly of bits for character transfer to computer and one for bit transfer to outgoing lines. The character assembly and computer transfer technique is shown in Figure 9

Unit can operate on a maximum receive bias and distortion of 46%

High Speed Buffer

The unit terminates up to 10 full duplex synchronous lines at speeds up to 2400 baud

The send and receive sections of the unit are independent, although both send and receive characters must be the same speed and code.

High speed line synchronization is provided by the SLB.

The module has the provision for detecting three consecutive open line characters (continuous space) or three continuous idle line characters (continuous mark). In each case a control word will be transferred to the processor

Receive characters will be checked for odd vertical parity Incorrect parity will result in the errored character being transferred to the processor but with indication that parity is incorrect.

Each outgoing character will contain the correct odd parity as generated by the module.

When a particular line of the module is "locked out" (that is, no characters are being transferred from the processor for

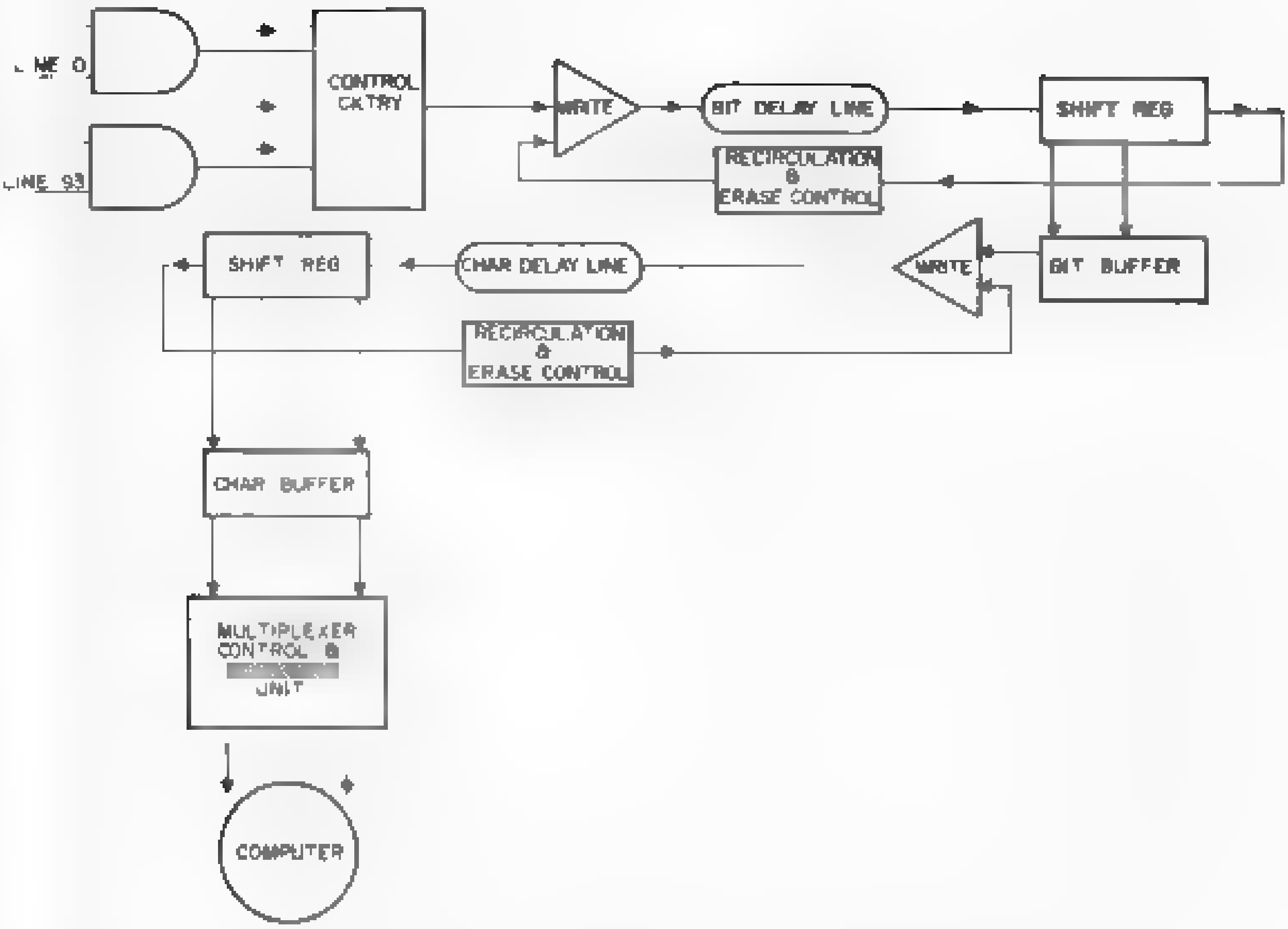

Figure 9. Character Assembly and Computer Transfer in COLMUX

ne transmission) synchronous characters will be continuously transmitted

The character transfer rate can be selected from among four options.

The transfer rate from the SLB to the processor is determined by the mode of operation and the characteristics of the processor

The unit can terminate 7, 8, 9-, or 10 unit codes

A single module can terminate two different speed code combinations. All lines of a speed code group use the same synchronous character and parity.

Each full duplex line of the module requires the use of a synchronous modem These units are not part of the COLMUX. The COLMUX will, however use the modem clocks for timing.

All sending lines belonging to the same speed/code group will operate from the same clock and therefore operate in synchronism

The SLB uses two delay line storage elements.

When operating in the Addressed Sequential Mode (request on a group basis) or Random Mode, each line of the module is assigned a unique identifying address.

In systems having more than one Line Buffer Unit, each unit is assigned a unique selection code. The selection code and the line identifying address will form a unique address for each line in a system

When operating in the Random Mode, the processor can prevent any line of the module from requesting data by transferring a STOP service command. This "lock-out" condition will be removed by the processor transferring a START command when data transmission is to be resumed

When power is initially applied to an SLB, all lines will automatically be "locked out." The processor must activate the lines by transfer of an individual START command to each.

Multiplexer Control and Interface Unit

The Multiplexer Control and Interface Unit (MCI) exercises interface control over the COLMUX It will select the Line Buffer Unit to be serviced The unit selected at a particular time depends on the number and kinds of Line Buffer Units being used. High speed units will be serviced more frequently than slower units.

The MCI generates processor external interrupts for signalling the processor and transfers all data and necessary control functions between Line Buffer Units and the processor.

The MCI will convert voltage levels, current drives, and timing pulses to and from the processor to levels, drives, and timing compatible with the COLMUX

Programmable Communications Controller

Various techniques have been described thus far describing relative methods by which computers may be interfaced with communication lines. These methods place varying degrees of dependence on the machine time of the computer as well as varying degrees of dependence on use of the stored memory of the computer When the computer is used mainly for message switch, the extent of this dependence may not be too important except from message load and growth factor Depending on the computer used, limited data processing can be accomplished in the background by the computer concurrent with the message handling. Due to the fact that many users of computers for message switch desire to perform considerable data processing a different type communication subsystem is required to prevent the frequent interruption of the computer data processing program with the communication chores Application of a small preprocessor or Programmable Communications Controller with the larger or host computer for data processing will permit use of a smaller memory in the host computer and will simplify the programming tasks for which the customer is responsible

This type of pre-processor is systems oriented, and in this case, communications control oriented. The PCC will divorce the communications functions from the data processing functions. This type of approach allows the PCC to be treated by the host computer as another batch transfer peripheral sub-system.

Potential Use

The use of PCC in Western Union's applications allows the efficient development of standard off the shelf hardware/software packages to perform the repetitive functions required on Western Union's standard communications lines. These include such functions.

(a) Insertion of Time and Date

(b) Parity checking on a character and block basis.

(c) Detection of special code sequences such as Start of Message, End of address, and End of Transmission.

(d) Control of Western Union's Standard Way Circuit Systems.

(e) Speed, format, and code conversions

(f) Monitoring of incoming lines, and responding with required control signals for Telex, Broadband, and other controlled lines.

Criteria for Use

A PCC should be modular enough to be capable of operating in various environments such as:

(a) Remote Concentrator/Deconcentrator: Characters from terminated low speed lines would be built into blocks or messages for transmission on high speed lines to remote locations. At these remote locations there would be similar PCC units for block or message disassembly, or message switching data processors.

(b) Small System Front End: In this application the Programmable Communication Controller would be used to terminate a small number of lines of both high and low speed types. All character checking, blocking checking, and line control functions would be performed by the PCC. Verified blocks or messages would be transferred over a high speed parallel data channel to a central processor for message switching.

(c) Large System Front End: In this application the Programmable Communication Controller would be used to terminate a large number of lines of both high and low speed types. The high speed terminations could originate from other PCC's operating as block or message concentrators deconcentrators.

(d) Message Switcher—The stored program feature of the PCC would allow small scale message switching functions to be performed.

To meet the varied demands of dedicated commercial message switch it is imperative that a PCC provide versatility, therefore, the concept of modular design must be provided. This allows for expansion and implementation.

ADDITIONAL OPERATIONAL COMPUTER ORIENTED SYSTEMS

Message Switch Way Circuit Systems

Four multi-station tributary computer oriented systems utilizing either a five level code (Baudot) or eight level code (ASCII), completely solid state controllers and operating either half duplex or full duplex are now operational. These systems are designed around wholly solid state circuitry and are designated Plans 115, 117, 135 and 137. These automatically polled and selected way circuit systems normally provide the low-cost backbone of a communication system and can be controlled by computers provided by either Western Union or by the customer.[8]

Communication Line Terminals (CLT)

A standard line of communication line terminals have been developed which allow the interfacing of Western Union's lines and or equipment with communication sub-systems provided by other than Western Union. These CLT's permit the consolidation on the customer's site any required data sets such as those needed for Western Union Class D termination.

Western Union's lines operating up to and including 75 baud can often connect directly to Patron provided computer communication sub-systems without the need of interface equipment. In some cases though Western Union provides CLT units to achieve line or equipment compatibility monitoring and line patching facilities.

For speeds 110 to 180 baud Western Union operates on a 4-wire basis and utilizes dc or ac data sets which are located on the customer's site. CLT units are available as indicated earlier which can accommodate up to 24 dc data sets in one cabinet. Two of these units are shown in Figures 10 and 11. Data sets in this range are available which conform with EIA standards for interfacing between data communication and data processing equipment.

For higher baud rates up to 2400 baud, Western Union data sets are available which provide a standard interface normally required by commercially available terminal units, that is they conform to EIA RS 232 B.

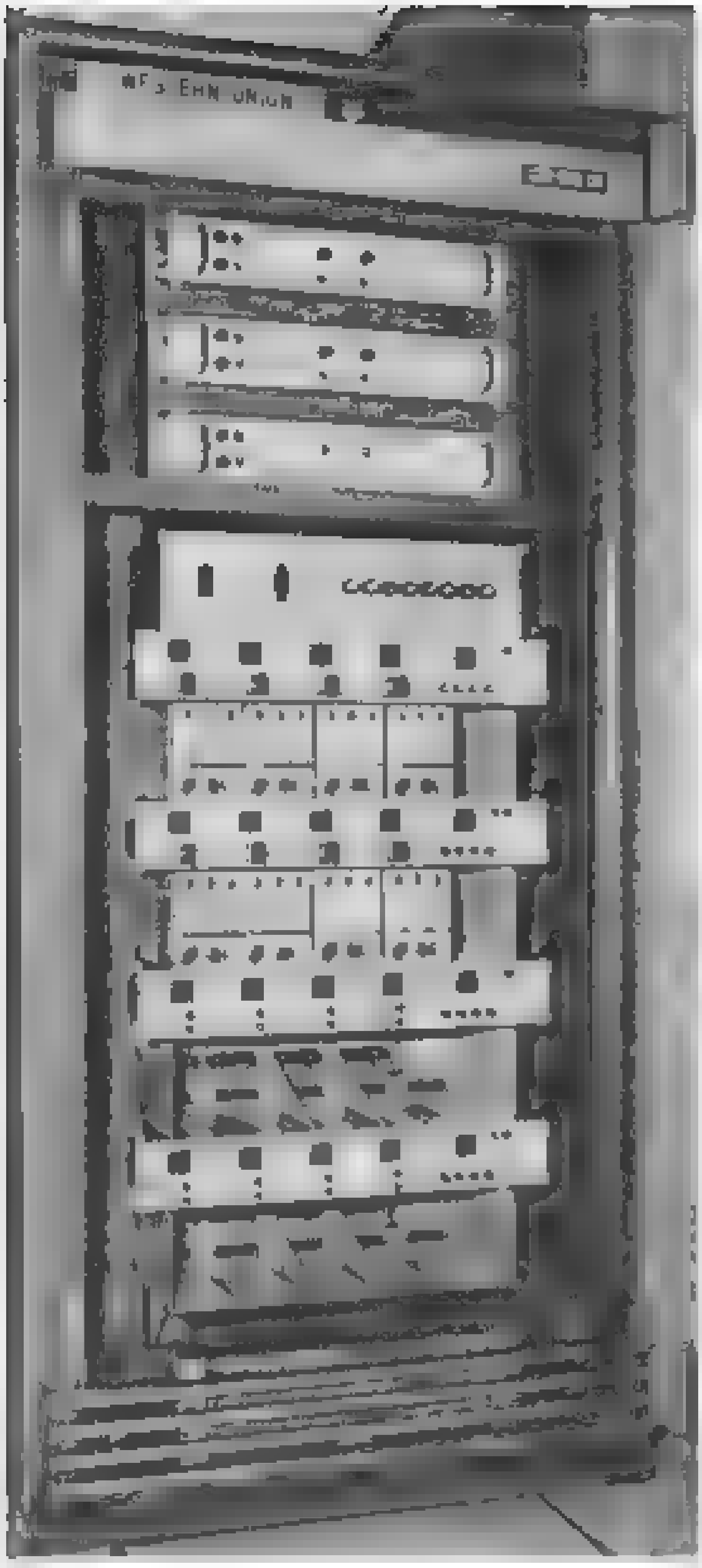

Figure 10.
Communication Line Terminal #11924

Communication Line Terminal #11924 mounts 24 relay transceivers or 24 low-voltage Class D data sets. It is an interface between the communication lines and the multiplexer of a CDC 8090 computer.

Communication Line Terminal #12487 interfaces between the communication lines and the Western Union COLMUX or the IBM 360 computer.

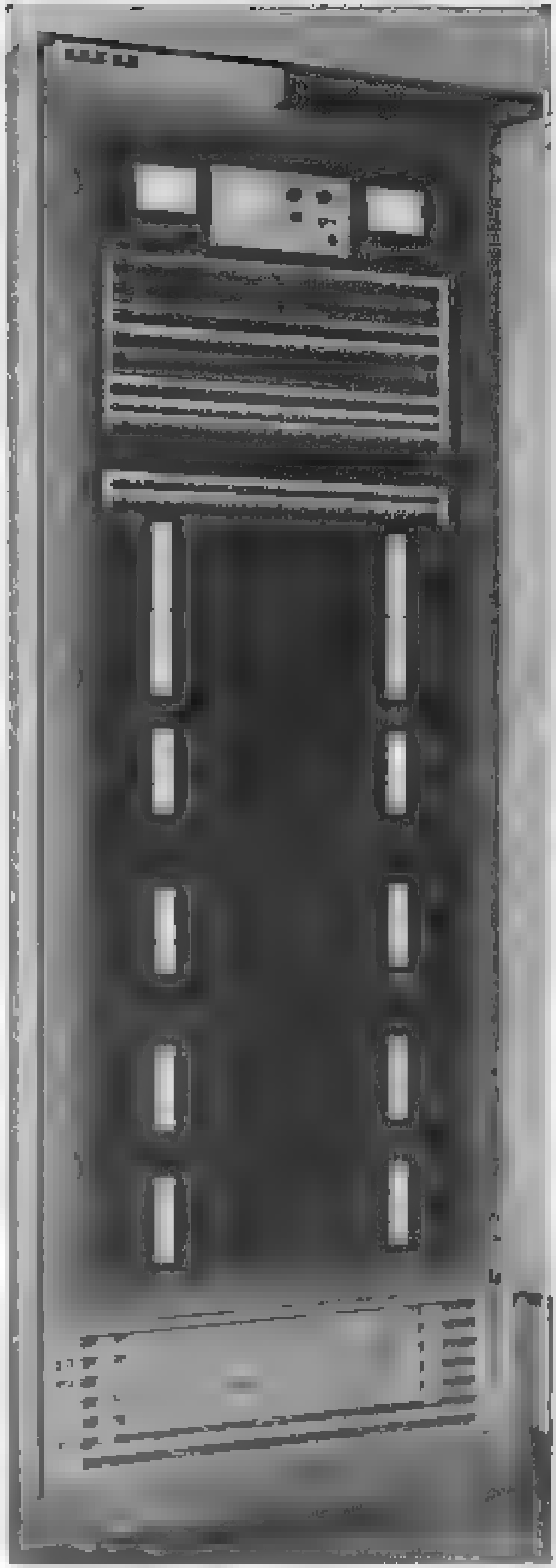

Figure 11
Communication Line Terminal #12487

Circuit Switch Access

The users of Western Union computerized message switch systems or patron provided computer systems may gain access into the Western Union Telex and Broadband circuit switch systems by application of specially designed Western Union hardware.

Western Union adapters are available, and, when interfaced with a computer, provide an on-line real-time link with the Telex network. This adapter can operate in an inquiry mode only or in a mode allowing the computer to originate messages into the networks. No special control channels are required between the adapter and the computer. All controls are accomplished via the send and receive data legs utilizing 5 level Baudot code.[4]

Also available are Western Union adapters which permit a computer to automatically originate calls on the Western Union Broadband exchange. Numbers to be dialed are passed between the computer and the automatic calling unit, via special leads one at a time in the form of binary electrical signals. The signals are converted to tone signalling by the adapter. Automatic answering devices permit completely unattended automatic operation between the calling and called stations.

Summary

It is apparent that a rapid technological change in digital communication is underway involving use of data processors as the controller element in message switch systems. Western Union is contributing to the change by designing and implementing a variety of computer control oriented communication subsystems capable of interfacing with data processors provided by either Western Union or the patron. These subsystems are indicative of the continuing efforts of Western Union to meet the demands of modern data communications functionally, efficiently and economically.

Acknowledgments

The author wishes to acknowledge gratitude to Messrs. E. Eberle, J. Elich and H. Jorgensen and members of their staff who contributed their part in the design and implementation of subsystems mentioned in this article.

References:

1. New W.U. 301 Computer Switching System, E. F. Manning, Western Union TECHNICAL REVIEW, Vol. 19 No. 2 (April 1965)
2. Communications Multiplexer for Computer Switching Systems, J. Elich and J. J. McManus, Western Union TECHNICAL REVIEW, Vol. 19 No. 2 (April 1965)
3. Duplex Way Station Systems, A. A. Ortiz, Western Union TECHNICAL REVIEW, Vol. 21 No. 1 (January 1967)
4. Telex Interface for Use with Computers, E. C. Mansfield, Western Union TECHNICAL REVIEW, Vol. 20 No. 3 (July 1966)

JOHN E. CALDWELL is Director — System Test and Evaluation in the Information Systems and Services Department.

He joined Western Union in 1952 and has had managerial and technical participation in all phases of system and circuit design as well as implementation on all of the private wire message switch and way circuit systems initiated by Western Union.

Message Switching
Government Systems
Switching Systems

Leonard, Robert H.: Message Switching in the ARS

Western Union TECHNICAL REVIEW, Vol. 21, No. 1 (January 1967)
pp. 2-13

The Advanced Record System (ARS) for the General Services Administration is a Telex Type Circuit Switch Network which has the additional capability of transmitting the message to the nearest Message Switching Center (MSC). Since the system was originally installed in February 1966, these Message Switching Centers have been incorporated to provide the capability of interchanging traffic with three AUTODIN centers and with the TWX network.

This article describes the services offered, the MSC hardware and software used by subscribers to the ARS, the input and output processing of messages.

This is the first time that users of the Advanced Record System have been provided with the advantages of a Circuit Switched Network and a Message Switched Network in one system.

Telex
Line Switching
Computer Techniques

Klein, Peter J.: International Telex Service through Computerized Line Switching

Western Union TECHNICAL REVIEW, Vol. 21, No. 1 (January 1967)
pp. 14-22

This article is a reprint of a paper presented at the National Electronics Conference sponsored by the I.E.E.E. in October 1966. Western Union Telex calls are transmitted overseas via anyone of three international carriers, RCA Communications Inc., ITT World Communications, and Western Union International, Inc.

This article describes the automatic computerized Telex circuit switching of one of these carriers, Western Union International, Inc. The special advantages of the system and the operation of the equipment are included.

Computerized Telex switching represents a significant advance in the application of data processing to the communications field.

Carrier Equipment
Multiplex
Voice Transmission

Maekask, T. Thomas: Cable Extension Systems for Carrier Multiplex Basebands

Western Union TECHNICAL REVIEW, Vol. 21, No. 1 (January 1967)
pp. 24-28

For the most economical and efficient transmission, carrier multiplex equipment can now be connected to its voice frequency input and output facilities by cable extension systems capable of handling basebands containing up to 960 voice channels.

This article describes the types of cables used, the performance characteristics of each, and the plans for expansion of existing multiplex and radio equipment to 1200 voice channels.

Announcements
AUTODIN

AUTODIN Expansion

Western Union TECHNICAL REVIEW, Vol. 21, No. 1 (January 1967)
p. 29

The 8th computer-operated communications center was opened at the Marine Corps Supply Center, Albany, Georgia. This expands the AUTODIN system from the original 5 centers to 8 centers for the Defense Communication Agency of the Department of Defense.

With the completion of the system all military departments of the Department of Defense and some other government agencies will be users of AUTODIN.

THESE ABSTRACT CARDS MAY BE CUT OUT AND PASTED ON LIBRARY CARDS FOR FILING.

SERVICE TO OUR READERS: As a service to our readership, articles will be abstracted so that a complete file may be kept for future reference.

Carrier Equipment
Multiplex
Microwave

Anderson, James L.: Pilot Alarm System for Carrier Multiplex

Western Union TECHNICAL REVIEW, Vol. 21, No. 1 (January 1967)
pp. 30-38

The TCS-600 carrier multiplex equipment associated with the Western Union Transcontinental Microwave Network has a unique Pilot Alarm System.

The components of the system, and the modulation plan for inserting and monitoring pilot tones in a carrier multiplex baseband are described in this article.

Way Circuits
Transmission
Control Systems

Ortiz, A. A.: Duplex Way Systems—Plan 117 and Plan 137

Western Union TECHNICAL REVIEW, Vol. 21, No. 1 (January 1967)
pp. 40-53

Plan 117 and Plan 137 have been used to provide communications networks for Western Union patrons engaged in such business and manufacturing, brokerage, etc.

A new duplex Way Station Selector was designed for use with these systems, Plan 117 and Plan 137.

Computer Techniques
Data Communications Systems
DALCODE

Caldwell, J. E.: Computer-Controlled Communication Subsystems

Western Union TECHNICAL REVIEW, Vol. 21, No. 1 (January 1967)
pp. 54-69

Western Union has designed a variety of computer control oriented communication subsystems capable of interfacing data processors provided by patrons of Western Union's services or by Western Union.

Several applications such as DALCODE and COLMUX are described in this article.

Announcement
Telephone
Voice Circuits

Transcontinental Hot/Line Service to Pacific Coast

Western Union TECHNICAL REVIEW, Vol. 21, No. 1 (January 1967)
pp. 72

The first transcontinental Hot/Line call from New York to Los Angeles for Western Union's new Hot/Line service was made on February 15, 1967.

Western Union circuits for the Hot/Line service are provided by the transcontinental Microwave System which assures high tonal quality and interference-free transmission.

hot/line transcontinental service to the pacific coast

Western Union's intercity, private line telephone service, featuring instant automatic connections, was officially inaugurated on February 15, 1967 when Shields & Company of New York made the first transcontinental Hot/Line call from New York to Los Angeles.

Western Union Hot/Line service is now available between New York and San Francisco. However, the service has been operating, between New York and Chicago, since July, 1965.

Hot/Line service works like this: a connection between cities is made instantly and automatically when the caller lifts the telephone handset, causing the distant telephone to ring immediately. A call may be originated from either city on the line.

Circuits for Hot/Line service are provided by Western Union's new transcontinental microwave system, assuring high-tonal quality, free from interference. The service will be expanded to almost all major cities in the United States within the next two years.